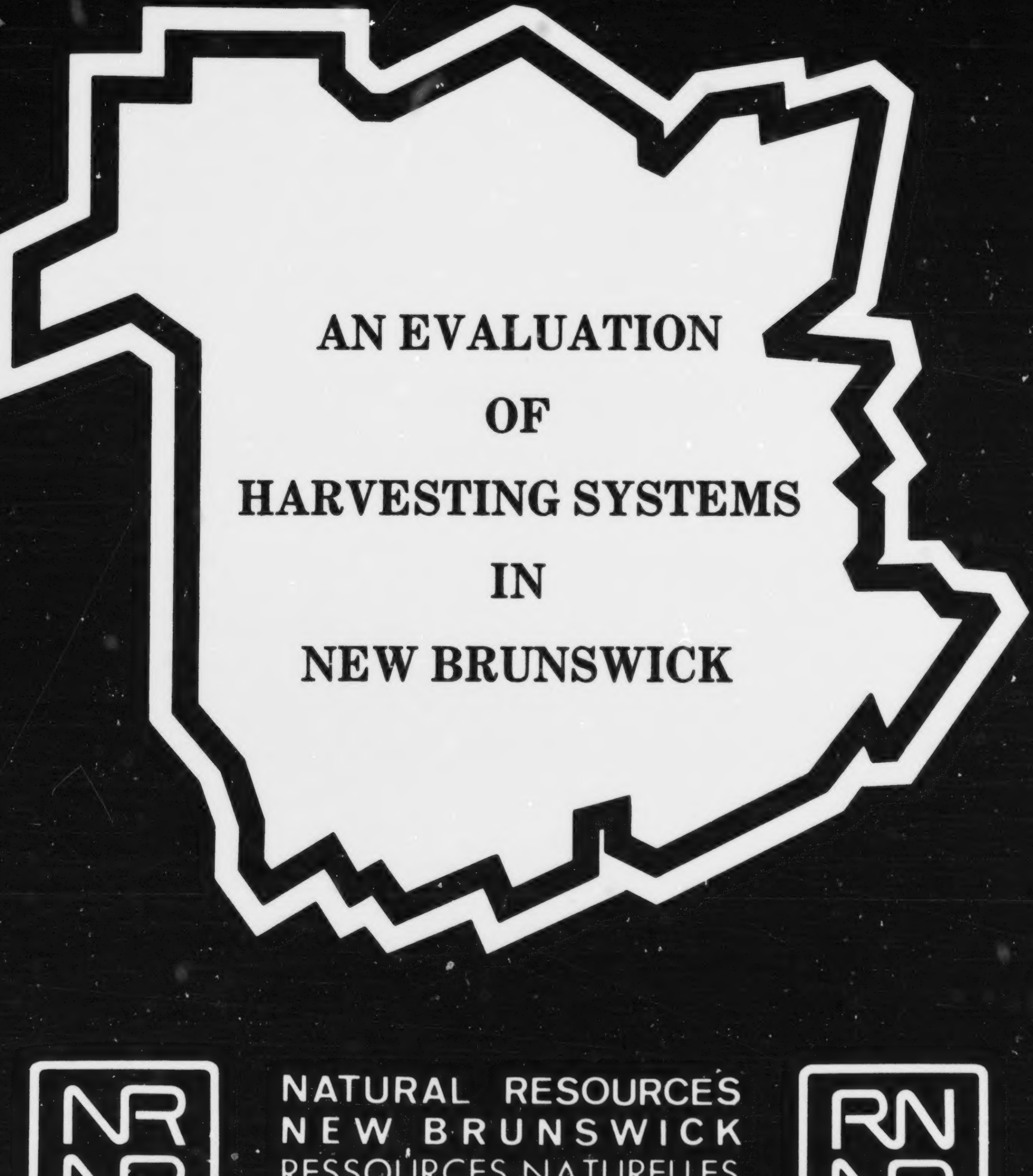
ISBN 0-88838-854-3



AN EVALUATION OF HARVESTING SYSTEMS IN NEW BRUNSWICK

NATURAL RESOURCES
NEW BRUNSWICK
RESSOURCES NATURELLES
NOUVEAU-BRUNSWICK

PRELIMINARY REPORT OF G.D.A. PROJECT 144.202 - EVALUATION OF HARVESTING SYSTEMS IN NEW BRUNSWICK

Department of Natural Resources

New Brunswick

"This is a Federal-Provincial Development Project, funded under the Forestry Subsidiary Agreement of the Canada - New Brunswick General Development Agreement by the Government of New Brunswick and the Department of Regional Economic Expansion."

Copies available from:

Public Information Section
Department of Natural Resources
P. O. Box 6000, Fredericton, N. B.
E3B 5H1

Authors:

David G. Black
Michael H. McDonald

ABSTRACT

An evaluation of various harvesting systems used to harvest timber on New Brunswick's Crown Lands is presented. The methodology and parameters used in the pre-harvest and post-harvest surveys is included. The effects that a particular harvesting system had on a specific site were assessed to determine the suitability of that system for harvesting environmentally sensitive areas to increase wood fibre supply while maintaining site quality within acceptable limits.

Although the harvesting systems studied did cause some ground disturbance, the severity of this disturbance should not hinder the capability of most areas to produce a future stand of timber. A large number of healthy seedlings remained on most of the study areas following the harvesting operations; however, the reduction in the number of plots with natural regeneration seemed to indicate that acceptable stocking standards may not be achieved. Proper supervision and block layout could have reduced merchantable waste and increased fibre utilization on all harvesting blocks.

It is concluded that on sites similar to those of the study areas, the harvesting systems evaluated in this report could be used to harvest riparian zones within acceptable environmental and economical constraints. Although production studies were beyond the scope of this report, it is anticipated that total wood cost would be slightly greater than on the adjacent cutover due to increased supervision and overall increase in forwarding distance.

An overall assessment of the study and recommendations conclude the report.

TABLE OF CONTENTS

Page

ABSTRACT i

TABLE OF CONTENTS ii

LIST OF TABLES iii

LIST OF FIGURES iv

INTRODUCTION 1

THE STUDY
  Study Procedures - General 3
  Study Procedures - Detailed 3
    Pre-Harvest Assessment 3
    Harvest 5
    Post-Harvest Assessment 5
  Discussion of Assessment Procedures 9

SUMMARY OF RESULTS 10

CONCLUSIONS 13

WOOD COST ANALYSIS 17

RECOMMENDATIONS 19

LITERATURE CITED 27

LITERATURE REVIEWED 28

APPENDIX I NORTH LITTLE RIVER LAKE STUDY AREA An evaluation of the Manual/Short-wood Harvesting System 29

APPENDIX II McCORMICK LAKE STUDY AREA An Evaluation of the Manual/Short-wood Harvesting System 43

APPENDIX III ROCKY LAKE STUDY AREA An Evaluation of the Mechanical/Full-tree/Short-wood Harvesting System 60

APENDIX IV ORMOND LAKE STUDY AREA An Evaluation of the Manual/Full-tree Harvesting System 74

Page

APPENDIX V CRYSTAL LAKE STUDY AREA 91
An evaluation of the Mechanical/Short-wood Harvesting System

APPENDIX VI BAYLES LAKE STUDY AREA 104
An Evaluation of the Mechanical/Full-tree Haresting System

LIST OF TABLES

		Page
Table 1.	PRE-HARVEST ASSESSMENT	10
Table 2.	GROUND DISTURBANCE	11
Table 3.	POST-HARVEST ASSESSMENT	12

LIST OF FIGURES

Page

Figure 1. Study Areas 3
Provincial map showing the general location of the study areas.

EVALUATION OF HARVESTING SYSTEMS IN NEW BRUNSWICK

by

D. G. Black
M. H. McDonald

INTRODUCTION

The Province of New Brunswick is in the process of changing from exploitive forest management to intensive forest management in order to maintain an available wood supply to meet the future consumption of New Brunswick's mills. The wood supply during this transition period must come from three sources: from what remains of the old forest that was put there by nature, from the regeneration on areas of forest already harvested in recent decades, and from a new forest that is being created by the efforts of intensive forest management (Baskerville, 1982). Since the availability of wood from these three sources is constrained in terms of the amount available, there could be a shortfall in the availability of softwood fibre during this transition period. A large portion of the wood supply will be from the existing forest and for this reason the amount of wood available from this source must be maximized over time.

Wood supply can be maximized by reducing mortality loss by the proper scheduling of harvest and protection activities, increasing utilization on harvested areas and harvesting restricted areas which are classified as inoperable terrain and environmentally sensitive areas such as riparian strips and deer yards. It has been estimated that restricted areas occupy approximately 15% of the Crown Land in New Brunswick and a significant portion of this area is in the form of riparian strips. Fibre from these areas could meet a portion of the mills' requirements during the transition period, provided it can be harvested within acceptable economic and environmental constraints.

This study evaluates individual mechanical and manual harvesting systems presently used on Crown Lands in New Brunswick for their suitability to harvest environmentally sensitive areas; primarily riparian strips. Each study area had different soil, terrain, stand, and machine characteristics. Although the interpretation of the results has led to some general overall conclusions, it is difficult to make comparisons between study areas and/or machine types. Conclusions were made for a specific site and machine type and if comparisons are attempted by the reader, the differences in sites and harvesting systems will have to be carefully considered.

THE STUDY

Study Procedures - General

Ten proposed harvesting blocks were selected throughout New Brunswick as study areas (Figure 1.) to determine whether the harvesting systems presently being used would be suitable to harvest riparian strips. The study was designed to provide a general assessment of a specific machine type on a specific site, without taking elaborate measurements of all factors, and much of the assessment was based on the subjective judgement of the field staff. Factors judged in a subjective manner will be described in following sections by written explanations. The harvesting systems could only be assessed on six of the original ten blocks selected. Three of the proposed areas were not harvested when the survey was being conducted while the fourth was scarified before a post-harvest assessment could be carried out. The six completed study areas are described separately in Appendices I through VI, each with its own results and conclusions. All areas were deemed to be sufficiently different as to make comparisons between areas and/or machine types difficult and unreliable. A final summation and recommendations for improving the study if future assessments are carried out will also be included.

Study Procedures - Detailed

Pre-Harvest Assessment

Prior to harvest, each block was assessed by locating cruise and regeneration sample plots along parallel transects spaced 140 m apart. Randomness of plots was assured by randomly locating the original starting point. Stand information was originally gathered from prism cruise points (BAF 2) located at 140 m intervals along the transects to provide a sample intensity of approximately two percent, however, this was found to be too time consuming so the sample intensity was decreased to one percent represented by points at 280 m intervals. Information on advance regeneration was gathered from 4 m^2 circular plots located at 70 m intervals along the transects. The term stocking, in the context of this report represents the percentage of sample plots containing at least one commercial species of healthy natural regeneration. Slope, ground roughness and ground strength were assessed in the general area of the plot. Slope was recorded by 5% slope class. Ground roughness was categorized into the following classes:

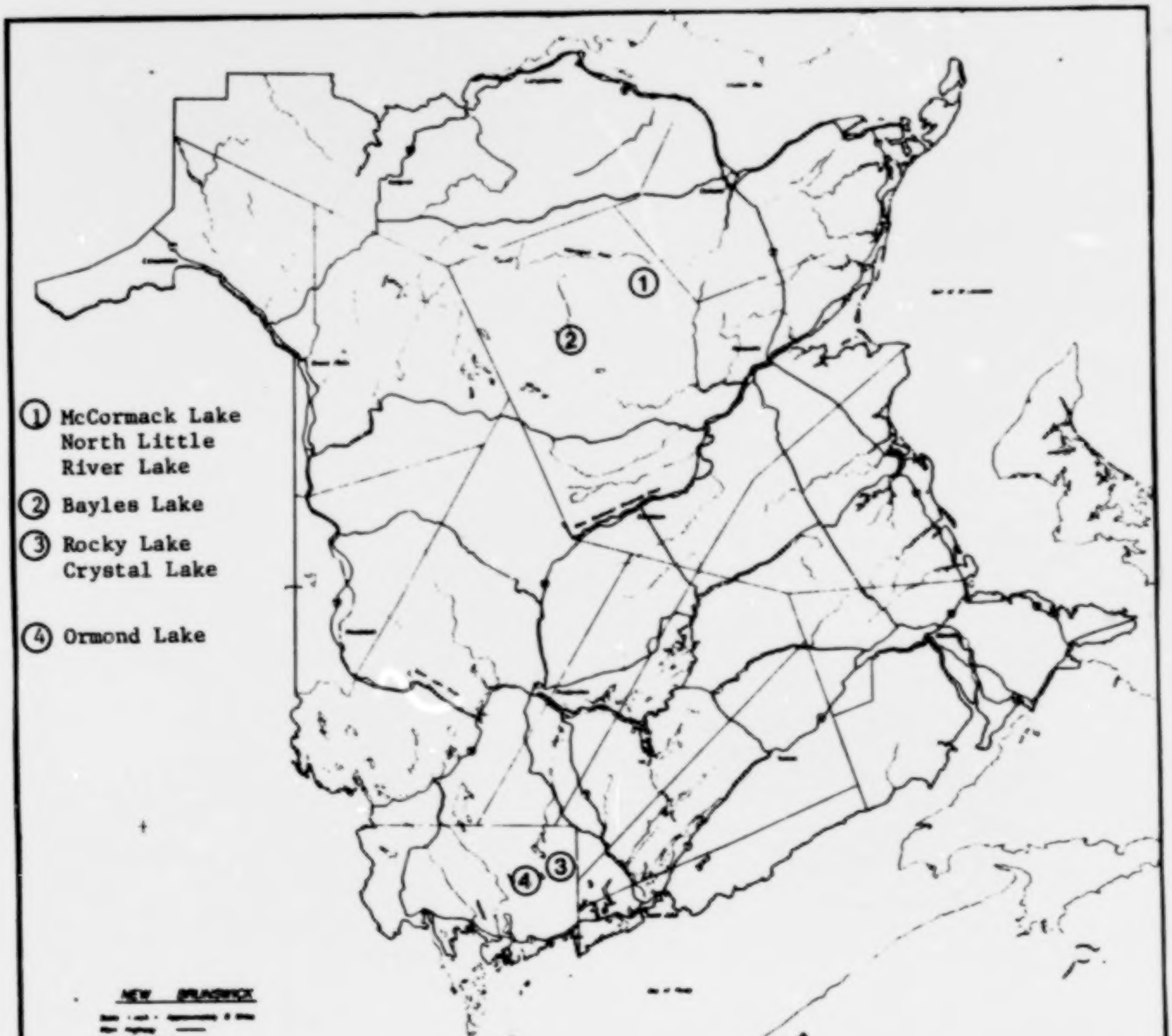


Figure 1.
Study Areas

(i) Class I - few if any significant obstacles (less than 1 m)

(ii) Class II - some obstacles impeding vehicle travel (i.e. boulders) but are usually avoidable.

(iii) Class III - significant obstacles impeding vehicle travel (i.e. boulders, bed rock ledges) and are often unavoidable.

Ground strength was classified using the system developed by the Forest Engineering Research Institute of Canada (FERIC)(P.G. Mellgren, 1980). Plots were temporarily located to enable post-harvest assessments of the same area.

Harvest

Harvesting took place with equipment and personnel normally associated with these types of operations. The study was designed and data collected in a manner which did not interfere with harvesting operations.

Post-Harvest Assessment

Post-harvest assessments were made as soon as the harvesting operation was completed.

The area occupied by roads and landings was determined by ground measurement as well as from post harvest aerial photography. Area was classified as either bulldozed or unbulldozed rather than as road or landing because on some blocks landings were not clearly distinguishable from roads.

Damage was assessed by relocating the 4 m^2 circular sample plots at or near the location of the pre-harvest assessment plots in the unbulldozed portion of the blocks.

The following information was recorded on each plot:

(a) An estimate of the portion of the plot occupied by each of the following classes of estimated number of machine passes.

(i) None - no passes of the machine.

(ii) Light - one pass of the machine.

(iii) Medium - two or three passes of the machine.

(iv) Heavy - four or more passes of the machine.

(b) An estimate of the portion of the plot occupied by each of the following classes of organic layer disturbance:

(i) None - no disturbance of the organic material other than being slightly compacted by machine travel; no tearing, gouging or removal of the organic layer.

(ii) Light - light gouging or scraping of the organic material.

(iii) Medium - considerable gouging, scraping or removal and redepositing of the organic layer and/or considerable compaction of the organic material.

(iv) Heavy - severe gouging, scraping or complete removal down to the mineral layer and redepositing of the organic material and/or severe compaction and lateral dislocation of the organic material.

(c) An estimate of the portion of the plot occupied by each of the following classes of mineral soil disturbance:

(i) None - no disturbance of the mineral soil.

(ii) Light - light gouging or scraping of the mineral soil.

(iii) Medium - considerable gouging or scraping of the mineral soil often to a depth of several centimeters.

(iv) Heavy - severe gouging or scraping of the mineral soil; deep rutting, blade scrapes or mucking of the soil.

(d) An estimate of the portion of the plot occupied by each of the following classes of slash accumulation:

(i) None - no accumulation of slash.

(ii) Light - slash is normally less than 10 cm in depth and discontinuous in distribution. Light slash is often associated with areas where no delimbing has taken place or only trees with a few branches have been delimbed. This class would include areas where slash consists only of a few small stems that have fallen to the ground prior to harvest or have been knocked to the ground during the harvesting operation.

(iii) Moderate - slash is evenly distributed and normally not more than one or two trees have been delimbed and/or topped on the same location. Slash is normally less than one metre in depth and is loosely piled. Moderate slash accumulation is often associated with a tree-length skidder operation.

(iv) Heavy - slash is abnormally concentrated because several trees have been delimbed and/or topped on that same location; slash would normally be greater than one metre in depth but slash less than one metre in depth could be classified as heavy if accompanied with slash compaction. Heavy slash accumulation is often associated with the rows of slash created by a manual trail cut system or by a roadside mechanical delimbing operation.

(e) A subjective classification of the limiting effect that soil disturbance and/or compaction, if present, would be expected to have on the regeneration potential of the plot:

(i) Not Limited - ground disturbance and/or compaction would not be expected to have any limiting effect on the ability of the area to be regenerated; slight disturbance may be beneficial.

(ii) Moderately Limited - ground disturbance and/or compaction would be expected to have some limiting effect on the ability of the area to be regenerated; exposure to hardpan, exposure to depths beyond the fertile layer, slight rutting, some compaction.

(iii) Severely Limited - ground disturbance and/or compaction would be expected to have a severe limiting effect on the ability of the area to be regenerated; exposure of large rock or bed rock, deep rutting, severe compaction, interruption of subsurface drainage, loss of soil structure due to mucking.

(f) A subjective classification of the limiting effect that slash accumulation would be expected to have on the regeneration potential of the plot:

- (i) Not Limited - uniform light slash accumulation would be expected to have little or no detrimental effect on regeneration potential; possibly some benefit provided by shading.
- (ii) Moderately Limited - moderate to heavy slash accumulation would be expected to have some detrimental effect on regeneration potential.
- (iii) Severely Limited - heavy slash accumulation often accompanied by some slash compaction would be expected to make regeneration very difficult.

(g) A subjective classification of the potential for soil erosion and siltation to occur based on the extent and degree of ground disturbance, slope and soil type:

- (i) Low - erosion and siltation unlikely to occur.
- (ii) Medium - erosion and siltation possible.
- (iii) High - erosion and siltation likely to occur.

(h) An estimate of damage to advance regeneration:

- (i) Undamaged - no visible damage has occurred and growth rate should not be adversely affected.
- (ii) Slight Damage - slight visible damage has occurred to the stem, foliage and/or roots but no significant adverse effect on growth rate should be expected.
- (iii) Moderate Damage - enough visible damage has occurred to the stem, foliage and/or roots such that a substantial setback in growth rate should be expected.
- (iv) Severe Damage - considerable damage has occurred to the stem, foliage and/or roots (stem breakage, uprooting) and the tree should not be expected to survive.

An estimate of fibre utilization was made on 0.05 ha circular plots located at 140 m intervals along parallel transects. Merchantable waste as defined in Regulation 84-231 under the Crown Lands and Forests Act was determined by the procedure described in the Forest Management Manual for Crown Lands 1982 (FMM).

Discussion Of Assessment Procedures

In general the method of assessment was found to be adequate. However there was some difficulty in determining the exact location of the pre-harvest assessment plots following the harvesting operations. Therefore in future the pre-harvest assessment plots will be relocated by measuring from the end points of the transect lines, which will be marked, to give an approximate location of the plots for post-harvest assessments.

This study did not involve a detailed assessment of compaction however compaction was incorporated into the assessment of organic and mineral layer disturbance.

SUMMARY OF RESULTS

The results of the harvesting system evaluation on the six study areas have been summarized in the following three tables. Appendices one through six present a more detailed assessment of these results for each study area as well as a discussion of the results and conclusions reached on an individual site basis.

Table 1 summarizes the information gathered by the pre-harvest cruise. Although the information presented is described in the study procedure or self-explanatory, an explanation of slope and branchiness classification is warranted. At each cruise point a slope was taken in the direction that the forwarding/skidding machines would travel loaded to roadside or to predetermined landings. An adverse slope would represent an "off-road" transport of the harvested material in an uphill direction, while a favorable slope would represent a downhill transportation of the harvested material. The branchiness classification describes the density and size of branches on the predominant tree species.

Table 2 summarizes the percentage of area, by slope, occupied by machine tracks, organic layer disturbance and mineral layer disturbance on the six study areas. As an interesting supplement the table includes a comparison made between ground disturbance caused by the harvesting system and the disturbance caused by scarifying the Ormond Lke site with chains and shark-finned barrels.

Table 3 presents a summary of the post-harvest assessment. Most of the headings are explained in the study procedure or are self-explanatory.

TABLE 1. PRE-HARVEST ASSESSMENT

	NORTH LITTLE RIVER LAKE	McCORMICK LAKE		ORMOND LAKE	CRYSTAL LAKE	DAYLES LAKE	ROCKY LAKE
		Southwest Area	East Area				
ECOREGION	New Brunswick Highlands	Restigouche-Bras D'Or	Restigouche-Bras D'Or	Magaguadavic-Hillsborough	Magaguadavic-Hillsborough	New Brunswick Highlands	Magaguadavic-Hillsborough
PREDOMINANT TREE SPECIES; NO. OF MERCHANTABLE STEMS PER HECTARE	Balsam Fir Spruce 794	Balsam Fir 836	Balsam Fir Spruce 667	Spruce 1 037	Spruce 782	Balsam Fir Spruce 855	Spruce 1 005
SECONDARY TREE SPECIES; NO. OF MERCHANTABLE STEMS PER HECTARE	White Birch Red Maple 130	Spruce 140	Red Maple White Birch 87	White Birch Red Maple Yellow Birch 205	White Birch Red Maple Eastern White Cedar 166	White Birch Red Maple 234	Red Maple White Birch Eastern White Cedar 125
NO. OF UNMERCHANTABLE STEMS PER HECTARE	327	1060	660	311	574	400	494
MERCHANTABLE SOFTWOOD(SW) VOLUME	101.0m³/ha	104.1m³/ha	113.4m³/ha	145.8m³/ha	111.3m³/ha	121.1m³/ha	116.4m³/ha
MERCHANTABLE HARDWOOD (HW) VOLUME	10.2m³/ha	2.3m³/ha	8.6m³/ha	32.6m³/ha	10.2m³/ha	23.2m³/ha	12.7m³/ha
BRANCHINESS CLASS % OF MERCHANTABLE TREE HEIGHT CONTAINING LIVE BRANCHES	Light 31-50%	Light - 30%	Light 31-50%	Light 31-50%	Light 31-50%	Heavy 31-50%	Light 31-50%
PREDOMINANT SLOPE	Favorable	Adverse	Adverse	Adverse	Favorable	Adverse	Favorable
PERCENT OF AREA IN THE VARIOUS SLOPE RANGES (0-5	30%	66%	68%	57%	52%	42%	40%
(6-10	37%	17%	16%	20%	16%	24%	30%
(11-15	23%	10%	13%	16%	20%	23%	13%
(16-20	10%	7%	3%	5%	12%	6%	2%
(21-25	-	-	-	1%	-	-	7%
(26+	-	-	-	1%	-	5%	8%
GROUND ROUGHNESS CLASSIFICATION	Class 1	Class 1	Class 1	Class 2	40% of area Class 1 60% of area Class 2	Class 1	40% of area Class 1 45% of area Class 2 15% of area Class 3
GROUND BEARING CAPACITY CLASSIFICATION	Good	Good	Good	Good	Good - some patches of poorly-drained low-lying areas; organic layer 100cm	Good	68% of area Good 22 % of area Moderate 10% of area Poor
SOIL TYPE	Stoney, sandy loam	Stoney, sandy loam	Stoney, sandy loam	Rock and boulders covered by a shallow gravelly loam	Shallow gravelly-loam	Stoney, sandy loam	Rock, Boulders covered by a thin layer of organic material and sandy loam
REGENERATION							
SOFTWOOD REGENERATION PER HECTARE	18 700	15 500	23 000	62 350	95 400	152 000	86 200
SOFTWOOD REGENERATION STOCKING	81%	69%	88%	79%	96%	97%	83%
HARDWOOD REGENERATION PER HECTARE	12 000	12 600	20 300	7 590	20 200	20 000	14 900
HARDWOOD REGENERATION STOCKING	81%	55%	84%	66%	50%	84%	53%
PERCENTAGE OF PLOTS WITH NEITHER HW OR SW REGENERATION	6%	21%	6%	7%	4%	2%	5%
AVG. HEIGHT OF REGENERATION	<50cm	<20cm	<20cm	<20cm	<15cm	<20cm	<20cm

TABLE 7. GROUND DISTURBANCE

- PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS' ORGANIC LAYER DISTURBANCE AND MINERAL LAYER DISTURBANCE

STUDY AREA (HARVESTING SYSTEM)	DEGREE OF DISTURBANCE	SLOPE %						
		0-5	6-10	11-15	16-20	21-25	26+	ALL SLOPES
		% of Cutover Area						
NORTH LITTLE RIVER LAKE (Manual/Short-wood)	PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
	- Light	-	6	6	11	-	-	5
	- Moderate	8	10	14	-	-	-	9
	- Heavy	-	-	-	-	-	-	6
	Total	8	16	20	11	-	-	15
	PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
	- Light	3	7	13	17	-	-	9
	- Moderate	-	3	-	-	-	-	1
	- Heavy	1	3	0	2	-	-	2
	Total	4	13	13	19	-	-	12
	PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
	- Light	-	-	-	-	-	-	-
	- Moderate	-	-	-	3	-	-	-
	- Heavy	1	-	-	-	-	-	-
	Total	1	-	-	3	-	-	-
CRYSTAL LAKE (Mechanical/Short-wood)	PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
	- Light	19	23	21	3	-	-	18
	- Moderate	10	6	10	-	-	-	8
	- Heavy	-	-	-	-	-	-	
	Total	29	29	31	3	-	-	26
	PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
	- Light	11	8	15	3	-	-	10
	- Moderate	2	10	-	-	-	-	3
	- Heavy	18	15	10	-	-	-	14
	Total	31	33	25	3	-	-	27
	PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
	- Light	-	10	2	-	-	-	2
	- Moderate	-	-	-	-	-	-	-
	- Heavy	-	-	-	-	-	-	-
	Total	-	10	2	-	-	-	2
ROCKY LAKE (Mechanical/full-tree/short-wood; Manual/short-wood)	PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
	- Light	19	14	25	-	-	4	15
	- Moderate	8	3	-	-	25	25	10
	- Heavy	9	23	-	100	25	8	13
	Total	36	40	25	100	50	37	38
	PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
	- Light	15	9	9	-	23	12	14
	- Moderate	2	4	9	95	1	3	5
	- Heavy	11	19	10	5	27	14	13
	Total	28	32	28	100	51	29	32
	PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
	- Light	4	2	0	5	4	8	3
	- Moderate	-	2	7	-	-	3	2
	- Heavy	5	16	3	-	25	-	8
	Total	9	20	10	5	29	11	13
BAYLES LAKE (Mechanical/full-tree)	PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
	- Light	17	18	34	28	-	4	21
	- Moderate	14	9	6	7	-	2	10
	- Heavy	6	14	2	-	-	2	7
	Total	37	41	42	35	-	8	38
	PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
	- Light	10	10	8	12	-	3	9
	- Moderate	8	5	3	-	-	2	5
	- Heavy	-	7	1	-	-	2	3
	Total	18	22	12	12	-	7	17
	PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
	- Light	2	-	1	-	-	1	1
	- Moderate	3	-	-	-	-	2	1
	- Heavy	-	7	-	-	-	-	3
	Total	5	7	1	-	-	3	5
MCCORMICK LAKE [Southwest Area] (Manual/Short-wood)	PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
	- Light	7	1	21	-	-	-	7
	- Moderate	-	-	-	50	-	-	4
	- Heavy	4	-	-	-	-	-	2
	Total	11	1	21	50	-	-	13
	PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
	- Light	4	-	-	38	-	-	5
	- Moderate	-	-	-	-	-	-	-
	- Heavy	-	-	-	-	-	-	-
	Total	4	-	-	38	-	-	5
	PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
	- Light	-	-	-	-	-	-	-
	- Moderate	-	-	-	-	-	-	-
	- Heavy	-	-	-	-	-	-	-
	Total	-	-	-	-	-	-	-
MCCORMICK LAKE [Eastern Area] (Manual/Short-wood)	PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
	- Light	5	1	4	8	-	-	4
	- Moderate	8	-	10	4	-	-	6
	- Heavy	-	10	-	-	-	-	2
	Total	13	11	14	12	-	-	12
	PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
	- Light	8	-	21	3	-	-	8
	- Moderate	1	11	-	-	-	-	2
	- Heavy	-	-	-	-	-	-	-
	Total	9	11	21	3	-	-	10
	PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
	- Light	1	-	-	-	-	-	1
	- Moderate	-	-	-	-	-	-	-
	- Heavy	-	-	-	-	-	-	-
	Total	1	-	-	-	-	-	1
ORMOND LAKE [Unscarified Area] (Manual/full-tree SW) (Manual/Tree-length HW)	PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
	- Light	4	12	6	-	-	-	6
	- Moderate	2	-	-	-	-	-	2
	- Heavy	7	-	6	-	-	-	6
	Total	13	12	12	-	-	-	14
	PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
	- Light	17	7	24	-	33	15	17
	- Moderate	3	-	-	-	-	18	2
	- Heavy	3	-	-	-	5	-	2
	Total	23	7	24	-	38	33	21
	PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
	- Light	1	-	-	-	5	3	1
	- Moderate	2	-	-	-	-	-	1
	- Heavy	-	-	-	-	-	-	-
	Total	3	-	-	-	5	3	2
ORMOND LAKE [Scarified Area] (Manual/full-tree SW) (Manual/Tree-length HW) (Shark-finned barrels & Chains)	PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
	- Light							
	- Moderate				N/A			
	- Heavy							
	Total							
	PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
	- Light	36	40	47	49	-	-	40
	- Moderate	32	29	10	23	-	-	27
	- Heavy	10	15	23	7	-	-	13
	Total	78	84	80	79	-	-	80
	PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
	- Light	6	12	7	3	-	-	7
	- Moderate	2	-	6	-	-	-	2
	- Heavy	-	-	1	-	-	-	1
	Total	8	12	14	3	-	-	10

TABLE 3. POST-HARVEST ASSESSMENT

HARVESTING SYSTEM	NORTH LITTLE RIVER LAKE	MCCORMICK LAKE		ORMOND LAKE		CRYSTAL LAKE	BAYLES LAKE	ROCKY LAKE
		Southwest Area	East Area	SCARIFIED PORTION	UNSCARIFIED PORTION			
	Manual/ short-wood	Manual/ short-wood	Manual/ short-wood	Manual/full-tree SW Manual/tree-length HW		Mechanical/ short-wood	Mechanical/ full-tree	Mechanical/full-tree/short-wood Manual/short-wood
AREA HARVESTED	41 ha	40 ha	89 ha	98 ha	74 ha	88 ha	95 ha	91 ha
ROADS & LANDINGS								
AREA OCCUPIED BY IN HECTARES	1.9 ha	1.3 ha	2.8 ha	8.2 ha		2.0 ha	9.4 ha	15.6 ha
PERCENT OF TOTAL CUTOVER AREA	4.6%	3.2%	3.2%	4.8%		2.3%	9.9%	17.1%
EROSION POTENTIAL								
PERCENT OF CUTOVER AREA WHICH (Low	100%	100%	97%	100%	95%	96%	95%	66%
MAY BE SUSCEPTIBLE TO EROSION (Medium	-	-	3%	-	3%	4%	5%	22%
(High	-	-	-	-	2%	-	—	12%
FIBRE UTILIZATION								
- VOLUME HARVESTED	6 949m³	4 256m³	10 860m³	25 213m³		14 871m³	14 505m³	11 766m³
- MERCHANTABLE WASTE	3.10m³/ha	5.20m³/ha	15.83m³/ha	4.32m³/ha		2.66m³/ha	4.63m³/ha	4.39m³/ha
- AVERAGE STUMP HEIGHT	17.3cm	13.1cm	8.7cm	9.9cm		17.3cm	11.3cm	16.2cm
- AVERAGE STUMP DIAMETER	19.9cm	16.2cm	18.2cm	21.6cm		21.9cm	16.9cm	18.7cm
- AVERAGE TOP DIAMETER OF SOFTWOOD (AND THE RANGE)	N/A	8.2cm ([illegible]cm-14cm)	8.7cm 6cm-16cm)	7.8cm (6cm-12cm)		N/A	7.6cm (4cm-16cm)	7.7cm (4cm-14cm)
- AVERAGE TOP DIAMETER OF HARDWOOD (AND THE RANGE)	N/A	9.0cm (6cm-10cm)	10.5cm (6cm-24cm)	10.7cm (4cm-22cm)		N/A	8.8cm (4cm-32cm)	9.7cm 6cm-14cm)
- ADDITIONAL AREA THAT COULD HAVE BEEN HARVESTED	15 ha	-	-	80 ha		16 ha	45 ha	29 ha
- ADDITIONAL MERCHANTABLE VOLUME THAT COULD HAVE BEEN HARVESTED	1 670m³	-	-	11 600m³		1 780m³	6 500m³	3 750m³
- TOTAL MERCHANTABLE FIBRE LEFT WHICH COULD HAVE BEEN UTILIZED	1 800m³	211m³	1 309m³	12 309m³		2 014m³	6 950m³	4 150m³
SLASH ACCUMULATION								
PERCENT OF CUTOVER OCCUPIED BY (none	19%	15%	36%	82%	52%	35%	10%	49%
THE CLASSES OF SLASH ACCUMULATION (light	42%	63%	32%	17%	36%	43%	90%	31%
(moderate	32%	15%	22%	1%	9%	9%	5%	4%
(heavy	7%	7%	10%	-	3%	13%	5%	16%
NATURAL REGENERATION								
SOFTWOOD REGENERATION PER HECTARE	11 000	14 600	12 000	35 000	51 800	52 500	62 000	15 500
PERCENT OF ORIGINAL SW REGENERATION	59%	94%	52%	14%	46%	49%	41%	18%
SOFTWOOD REGENERATION STOCKING	70%	69%	55%	19%	57%	67%	90%	43%
HARDWOOD REGENERATION PER HECTARE	4 300	2 100	1 200	500	200	520	1 000	220
PERCENT OF ORIGINAL HW REGENERATION	36%	17%	6%	5%	7%	3%	5%	15%
HARDWOOD REGENERATION STOCKING	43%	21%	17%	6%	7%	13%	15%	3%
% OF PLOTS WITH NEITHER SW OR HW REGENERATION	20%	29%	59%	76%	40%	33%	10%	57%
REGENERATION POTENTIAL								
PERCENT OF CUTOVER AREA (Not Limited	100%	100%	97%	90%	72%	30%	98%	58%
USING SOIL DISTURBANCE (Moderately Limited	-	-	3%	6%	19%	48%	2%	27%
AS THE LIMITING FACTOR (Severely Limited	-	-	-	4%	9%	22%	-	15%
PERCENT OF CUTOVER AREA (Not Limited	58%	71%	67%	85%	86%	29%	95%	59%
USING SLASH ACCUMULATION (Moderately Limited	23%	22%	22%	10%	8%	50%	-	19%
AS THE LIMITING FACTOR (Severely Limited	19%	7%	11%	5%	6%	21%	5%	22%
PERCENT OF CUTOVER AREA USING THE NATURAL CONDITION OF THE SITE AS THE (Not Limited	90%	50%	72%	82%	83%	23%	N/A	23%
LIMITING FACTOR (Moderately Limited	7%	33%	21%	15%	9%	45%	N/A	42%
(Severely Limited	3%	17%	7%	3%	8%	32%	N/A	35%
PERCENT OF CUTOVER AREA USING SOIL DISTURBANCE SLASH ACCUMULATION AND/OR THE NATURAL CONDITION OF (Not Limited	55%	55%	52%	74%	64%	13%	93%	25%
THE SITE AS THE LIMITING (Moderately Limited	23%	30%	35%	17%	21%	54%	2%	31%
FACTOR (Severely Limited	22%	15%	13%	9%	15%	33%	5%	44%

CONCLUSIONS

With the exception of the mechanical/full-tree/short-wood system used on the Rocky Lake Study Area, the harvesting systems evaluated did not appear to cause any major damage to their respective sites. The excessive amount of ground disturbance on the Rocky Lake site, however, may have been more dependant on the poor quality of the site rather than the type of harvesting system used. A conventional manual/tree-length system would have probably caused similar results. A harvesting system employing an "off-ground" forwarding of the wood such as a manual/short-wood system would probably have done the least amount of damage.

The area occupied by roads and landings exceeded the Forest Management Manual (FMM) requirement on both the Rocky Lake and Bayles Lake Study areas. A distinctive characteristic of a full-tree harvesting system is that the landings, whether located at roadside or scattered throughout the cutover, generally occupy a larger area than either of those found on conventional tree-length or short-wood operations. A greater effort in predetermining the number and locations of landings should be a pre-requisite for a full-tree logging operation so that the area occupied by landings can be kept to a minimum.

As might have been predicted the percentage of cut-over area occupied by machine tracks was higher on the mechanical operations. It seems reasonable to assume that the more machinery involved in felling, forwarding and processing, the higher this percentage will be. The percentage of area occupied by organic and mineral layer disturbance was likewise greater on the mechanical operations. A marked increase in organic layer disturbance was also observed on areas where the wood in full-tree form was skidded to landings rather than forwarded, however, mineral layer disturbance remained minimal on most sites with the exception of the Rocky Lake cutover. On the majority of the blocks the percentage of area occupied by organic and mineral layer disturbance appeared to increase with increasing slope, however, the severity of this disturbance did not. The Crystal Lake and Bayles Lake cutovers did not follow this trend. On the Crystal Lake site the percentage of area disturbed as well as the severity of that disturbance did not appear to increase with increasing slope. On the Bayles Lake site the amount of ground disturbance appeared to decrease for slopes greater than 20%.

The percentage of area occupied by heavy slash accumulation was found to be greatest on the Rocky Lake and Crystal Lake sites. On both of these mechanical operations, the processing phase, i.e. limbing and topping, took place within the cutover area and not at roadside. The manual/short-wood harvesting system was next in line in terms of area occupied by heavy slash accumulation followed by the full-tree system; either mechanically felled or manually felled, where the processing phase occurred at roadside landings. Full-tree harvesting to roadside landings does make it advantageous for future scarification and artificial reforestation practices, however, the system does produce rows of dense, compacted slash, the underlying area of which will be difficult to reclaim to a tree producing capacity, at least within one rotation period.

A considerable amount of natural regeneration was destroyed on all but the southwest portion of the McCormick Lake Study Area during the harvesting operations. Since there are no requirements in the Forest Management Manual (FMM) outlining minimum acceptable regeneration densities and stocking for a cutover area immediately following a harvesting operation, it is difficult to conclude whether or not the post-harvest natural regeneration will be sufficient for the area to attain a certain specified level of productivity and yield within a certain time frame. However, the FMM does state that harvested areas will be considered sufficiently regenerated to attain their specified level of productivity and yield when, in the fifth year, they have a stocking level of at least 60% of commercial species and the dominant species composition must be within 10% of the forest unit specification in the individual Licensee's wood-supply analysis. Therefore the author has assumed that the cutover areas will be sufficiently regenerated if the post-harvest assessment shows a minimum stocking of at least 60% and a minimum density of 2 000 stems per hectare of healthy spruce and/or balsam fir natural regeneration (on all six study areas the predominant tree species was spruce and/or balsam fir).

Softwood (spruce and/or balsam fir) natural regeneration densities were well above the 2 000 stems per hectare on all the cutover sites. This indicates that if left to grow in a natural state a thinning treatment will probably be required for these cutovers at some future date. The minimum stocking requirement of 60% was not attained on the Rocky Lake, Ormond Lake and the eastern position of the McCormick Lake Study Areas. The reduced stocking of softwood regeneration on the Rocky Lake and Ormond Lake sites was a result of the full-tree skidding phase of the harvesting operations. Regeneration plots near or on skidtrials were left void of natural regeneration as a result of the disturbance caused by the dragging action of the full-trees over the site. An explanation for the reduction in softwood regeneration stocking on the eastern portion of the McCormick Lake Study Area is somewhat clouded. The manual/short-wood harvesting system used on the site did not cause a great deal of ground disturbance as indicated in Table 2. The only probable cause for the regeneration damage may be attributed to the sudden exposure of the softwood seedlings to direct sunlight. The high natural softwood regeneration stocking on the Bayles Lake site following the mechanical/full-tree operation could be attributed to the fact that the full-trees were forwarded to roadside landings eliminating damage that might have been caused by a skidding operation.

The percentage of cutover area severely limited to natural regeneration potential was greatest on the Rocky Lake and Crystal Lake sites. On both mechanical harvesting operations the natural condition of the site appeared to be the most limiting factor to regeneration potential. However, soil disturbance and slash accumulation on both sites were influencing factors as well. Regeneration potential was greatest on the Bayles Lake site which was harvested by the Koehring Feller Forwarder. This indicates that a harvesting system using an "off-ground" forwarding concept and slash accumulation at roadside landings enhances the potential of the cutover area to regenerate by natural means, depending of course on the quality of the site.

Erosion and siltation potential was generally low on all sites, however, the Rocky Lake Study Area was an exception. Moderate to heavy ground disturbance caused by the interaction of the harvesting machinery with the poor quality of the site created severe rutting and gouging of the mineral layer which will be quite susceptible to erosion.

The post-harvest assessment indicated that merchantable waste exceeded $3.0m^3/ha$ on all but the Crystal Lake Study Area. The majority of this waste was in the form of small diameter trees either left on the cutover or buried in slash piles. The maximum 30 cm stump height regulation was adhered to an all study areas. The average top diameter of softwood and hardwood indicated that merchantable softwood trees were being better utilized than hardwood trees. The average top diameter of softwood trees indicated that better utilization was occurring on cutover areas where the trees were felled and processed by mechanical means.

On all but the McCormick Lake Study Area proper planning and block layout could have yielded substantial volumes of merchantable wood left standing between the edge of the cutover and the prescribed riparian zone. Unless additional logging roads are constructed through the regenerating or planted cutovers this amount of merchantable timber will in all likelihood never be cut.

Under proper supervision most of the harvesting systems evaluated could be adopted to harvest riparian strips within acceptable environmental and economic constraints. Certainly some of the harvesting systems evaluated work best when large areas can be cleared with room for maneuvering the harvesting machinery. Selective cutting within riparian zones, for example, would be difficult to accomplish with the mechanical/full-tree or mechanical/short-wood systems. Furthermore by using a selective cutting method, harvesting machines would be restricted in where they could travel. However, the mechanical harvesting systems as well as the other systems evaluated could be adapted to harvesting riparian zones by using wide strip cuts, patch cuts or smaller clearcuts within the zones.

From a production and economic point of view, it would be beneficial to harvest riparian zones adjacent to a designated cutover. Logging roads could be properly planned so that skidding and/or forwarding distances would be of similar length to that on the adjacent cutover. Also as cutting progresses on the adjacent cutover, the effects that the particular harvesting system has on the site can be used to predict whether or not, under certain environmental constraints, those effects would be similar to what may occur as the riparian zone is harvested.

The sensitivity of riparian zones to water quality and fish and wildlife concerns necessitates proper planning and supervision in harvesting any portion of that zone. The disturbance caused by any one of the harvesting systems evaluated must be kept to a minimum. Riparian zones contain a valuable volume of merchantable timber and only through proper intensive forest management can this timber be harvested while also preserving the benefits that those zones confer on fish and wildlife species.

WOOD COST ANALYSIS

The suitability for harvesting riparian zones with the harvesting systems evaluated has already been discussed for each study area. The general conclusions reached were based on the site-specific characteristics of riparian zones and the predicted limitations of each harvesting system within these zones. Although no production studies were carried out, some general conclusions can be drawn on the economic feasibility of harvesting riparian zones by estimating the effects on total wood cost.

If riparian zone widths adjacent to specified cut blocks conform to the guidelines in the FMM, they would not normally be wide enough to alter road construction patterns so that road construction cost per unit of wood should drop slightly. Although riparian zone widths were in excess of the guidelines on five out of the six study areas, they were not wide enough to alter the road construction patterns. Additional logging roads would only be needed on the Ormond Lake Study Area.

On all the study areas some increase (unless cost is based on a piece rate) in forwarding cost per unit of wood should be expected. This is only on the assumption that tree size and the quality of the wood is similar to the adjacent cutover. The cost increase in the forwarding or skidding phase will depend on the width of the riparian zone. On narrow riparian zones the forwarding cost increase should be relatively small; however, wider zones should generate a corresponding increase in the forwarding cost per unit of wood.

Site specific factors such as increased slope, ground roughness and poor ground bearing strength will decrease productivity and will increase wood cost depending on how much these factors deviate from the adjacent cutover. On the study areas evaluated there did not appear to be a significant difference in site characteristics between the riparian zones and the adjacent cutovers suggesting that any increase in wood cost due to the terrain conditions would be minimal.

The type of harvesting method prescribed for harvesting riparian strips may affect productivity. Selective cutting may reduce felling and forwarding production because of the need in both harvesting phases to manoeuver around standing trees. However, this assumption can only be made if the average tree size and wood quality is equivalent to that on the adjacent cutover. Increased tree size and improved wood quality within the selectively cut area may negate any decrease in production. Patch and strip cuts may cause a decrease in productivity due to increases in machine delays caused by difficulties in maneuvering within confined boundaries and difficulties in accumulating a full load once the forwarding machines have started into the strips.

The largest increase in an individual component of total wood cost for harvesting riparian zones adjacent to cutovers may be the extra manpower requirements in planning and supervising the cut. The environmental limitations and constraints placed on riparian zone harvesting requires additional planning and increased supervision to minimize damage to the site while maintaining an acceptable level of production. Areas of low ground bearing capacity, inoperable slopes, rough ground, etc., should be avoided and marked in such a way that the machine operators can alter their course to avoid these areas with as little disruption or delay as possible. Strip or patch cuts could be flagged designating the areas to be left standing. Depending on the site conditions, skid trails could be marked so that continued vehicle passes over the same area are located in areas where the least amount of damage will occur. The cost per unit of wood harvested of this extra planning and supervision may be several times the cost of the supervision on the adjacent cutover; however, the effect of this component on the total wood cost should be quite small.

RECOMMENDATIONS

1. FUTURE EVALUATIONS OF HARVESTING OPERATIONS SHOULD BE MORE DIVERSIFIED TO INCLUDE A VARIETY OF HARVESTING SYSTEMS UNIFORMLY DISTRIBUTED AMONG THE VARIOUS LICENCES AND ECO-REGIONS OF THIS PROVINCE

It was unfortunate that the study areas chosen for the harvesting system evaluation were grouped on two Crown Timber Licenses and confined to only three specific ecoregions. Confining the study to two specific licenses eliminated the opportunity to evaluate a variety of machines and harvesting systems. For example, the conventional manual-fell/tree-length skidding system was excluded from this study, while the manual/short-wood system was evaluated on two similar sites.

There are seven different ecoregions within New Brunswick, distinctive in character by the types of vegetation, species composition, stand distribution, climate, geological formation, soil types, silvicultural responses, etc. Restricting the study areas to only three of these ecoregions eliminated the opportunity to assess harvesting systems on a broader spectrum of sites.

Future evaluations of harvesting systems should be more widespread and uniformly distributed among the various Licenses and ecoregions of this province.

2. FUTURE PRE-HARVEST AND POST-HARVEST ASSESSMENTS IN EVALUATING HARVESTING SYSTEMS SHOULD BE CONDUCTED BY THE SAME PERSONNEL.

Determining the amount of disturbance to the organic and mineral layer and the number of machine passes over a specific area of the cutover required a subjective judgement. Although the percentage of area and severity of ground disturbance could be accurately evaluated, it was difficult on some plots to estimate the number of machine passes within the parameters (one or two passes) outlined in the study procedures. As such, information gathered and results formulated depended on the integrity and consistency of the survey crew. The time span required to do the pre-harvest survey, observe the harvesting and complete the post-harvest assessment was such that it was difficult to retain the same personnel to do all three phases. Although accurate notes were recorded, familiarity with aspects of the study area would have been an asset.

3. PERMANENT RE-MEASURABLE PLOTS SHOULD BE ESTABLISHED SO THAT LONG-TERM EFFECTS OF HARVESTING OPERATIONS CAN BE MONITORED

Conclusions reached on the effects that the harvesting systems had on natural regeneration potential on the study areas were based on data collected within one year after the harvesting operation. Of course, factors affecting growth and future stand development are not limited to such subjective speculation. Numerous physiological factors affecting growth and composition of the future stand are beyond the intent and scope of this report. Long-term effects can only be monitored by the establishment of permanent re-measurable plots.

4. PROPER PLANNING AND HARVEST BLOCK LAYOUT SHOULD BE BASED ON SOUND FOREST MANAGEMENT PRINCIPLES AND NOT ON GEOMETRIC DESIGN.

The location of cruise lines and the subsequent pre-harvest survey were based on the Licensee's block layout contained in their five-year operating plan. In most cases the final shape and location of the block did not reflect the preliminary layout configuration. Subsequently some of the permanent cruise points fell outside the cutover area and were eliminated from the post-harvest assessment. From a forest manager's point of view the size, shape and location of the cutover depends upon the degree of damaged wood, stand maturity and species composition, site-specific and general wildlife habitat considerations, natural boundary features, and the proximity to adjacent clearcuts. From a logger's point of view the size and shape of the cutover depends on the type of soil, terrain characteristics, volume of merchantable timber and the type of harvesting system to be used. As mentioned in the introduction, the availability of softwood fibre is at a critical stage where proper planning and scheduling of the annual cut is essential. A crucial first step in realizing this goal is proper block layout. The shape and size of clearcuts should not be based on geometric design, 'the perfect rectangle', as much as on sound forest management principles.

All the cutovers evaluated were bordered on one or more sides by streams or lakes. The width of the riparian zone left between the cutover and the watercourse should establish the boundary of the clearcut. A substantial volume of merchantable timber was left on most study areas between the edge of the cutover and the edge of the riparian zone. Without the construction of additional logging roads, or forwarding this timber through the already planted or regenerating cutover, these isolated strips of standing timber may never be harvested.

5. RIPARIAN ZONE WIDTHS SHOULD BE PRESCRIBED ON AN INDIVIDUAL WATERCOURSE BASIS AND THIS RIPARIAN ZONE BOUNDARY ADJACENT TO CUTOVER AREAS SHOULD BE USED AS THE HARVEST BLOCK BOUNDARY.

There are no specified required widths for riparian zones in the FMM although there are guidelines which suggest that minimum horizontal buffer zone widths be 15, 30 and 60 m on bank slopes of 0-5%, 6-10% and greater than 10%, respectively. These guidelines were established to maintain water quality and to protect fish habitat. Consideration of a number of factors such as provision for wildlife habitat, aesthetic and recreational value, may require wider riparian zones.

All watercourses are unique in their value and characteristics and as such should be treated on an individual basis. This makes it difficult to assign a set of quantitative widths to apply for all riparian zones within the province. All watercourses adjacent to or part of a harvest block should be inspected in the field. The biologists' evaluation should indicate the required riparian width to maintain water quality and fish habitat, to satisfy wildlife habitat and to assess the aesthetic and recreation value of the zone. The forester's evaluation should indicate age of the zone, quality of the wood, species composition and whether or not the topography will inhibit harvesting operations. The regional resource manager must then assess the condition of the riparian zone in terms of its present and future economic value as well as the benefits it confers on fish and wildlife species.

Riparian zone widths must be prescribed on this individual basis so that the optimum compromise between fish and wildlife concerns and available softwood supply can be realized.

6. ALTHOUGH MERCHANTABLE WASTE WAS EXCEEDED ON FIVE OUT OF THE SIX STUDY AREAS, DNR'S MAIN CONCERN SHOULD BE REDUCING MERCHANTABLE WASTE DUE TO POOR PLANNING AND BLOCK LAYOUT.

The Crown Lands and Forests Act prohibits wasteful cutting practices on Crown Lands. Wasteful cutting practices include:

(1) cutting any tree so that the stump height is greater than 30 cm above average ground level;

(2) not bringing to roadside any merchantable tree or merchantable bolt, identified in an operating plan as a species to be cut, whether the merchantable tree or merchantable bolt is cut, uncut, lodged or bulldozed;

(3) long-butting any merchantable tree which is not a cull under the Scalers Act

(4) cutting or damaging any tree not specified to be cut in an operating plan.

A merchantable bolt means any primary forest product equal to 2.44 m in length at an 8.0 cm top diameter outside bark. A merchantable tree means any tree which contains at least one merchantable bolt.

The Department of Natural Resources (DNR) recognizes that a certain amount of merchantable wood will be left on a block following a harvesting operation. There are a number of factors which may contribute to this, such as the lack of proper supervision on the job site, the harvesting system and method of cutting, the species composition, condition and size of the trees and the condition of the site relating to ground roughness and bearing capacity. The Department tolerates 3.0 m^3/ha of merchantable wood left on a block and the Regional Resource Manager (RRM) may request the Licensee to report merchantable waste volumes for any harvesting operation on the License. It is then up to the discretion of the RRM if penalties are to be assessed on blocks not meeting the 3.0 m^3/ha requirement.

The waste analysis conducted as part of this study indicated that the amount of merchantable wood left on the block following the harvesting operation exceeded 3.0 m^3/ha on five out of the six blocks. The majority of this waste material (72% for all six blocks) was in the form of full trees, usually less than 10 cm diameter at breast height. There seemed to be no correlation between the type of harvesting system used and the amount of merchantable waste remaining on a particular block.

Although the merchantable waste requirement was exceeded on five out of the six blocks, it would be presumptuous to assume that this same percentage could be projected for all blocks harvested on Crown Lands. It does point out, however, the need for the Department to investigate more cutovers to ensure the merchantable waste requirement is not being exceeded to the degree on which it occurred on these study areas.

Although the concern for reducing merchantable waste on a cutover area is a legitimate step in increasing overall utilization, the volume of merchantable material left on the study areas was a "drop in the bucket" compared to the volume of wood left standing as a result of poor block layout. Of the total volume that could have been harvested on the six cutovers, 4% of that volume was merchantable waste on the cutover resulting directly from the harvesting operation while 29% of that volume was left standing between the edge of the cutover and the approved riparian zone. The preoccupation with tops and bolts, small diameter trees, long-butts, skids and logs in the cutover seems frivolous when the total picture is painted. There are a number of penalties which may be levied to deter merchantable waste in cutovers but what is the penalty for poor block layout, other than reflecting poor forest management?

7. DECISIONS ON THE FUTURE ESTABLISHMENT AND DEVELOPMENT OF A CUTOVER AREA SHOULD BE MADE PRIOR TO THE HARVESTING OPERATION.

Historically, in this province, there has been a dis-association between the harvesting phase and the silvicultural phase in managing a forest stand. The cost at which a unit of wood is produced was the overriding factor determining how and when a stand was harvested. Silviculture was perceived as an unrelated post-harvest remedy to secure a volume of merchantable wood at some future date. However, in the province's transition to intensive forest management, the forest industry has come to accept that scheduling harvest blocks, choosing the harvesting systems, cutting methods, site preparation, planting, thinning, etc., are all silvicultural tools used in the proper management of the forest resource. Understanding the relationships that any one of these factors has in maintaining and improving forest stands is a fundamental goal for sound forest management.

Clearcutting the province's softwood stands is an accepted silvicultural technique reflecting the fact that the majority of the softwood stands are overmature and susceptible to budworm damage.

Stand establishment following a clearcut operation can be accomplished by using two alternatives: relying on natural regeneration to reforest an area, or by artificial reforestation. Whatever decision is made on the future establishment and development of a clearcut, it should be made prior to the harvesting operation. On areas where natural regeneration will be relied on to reforest an area, the harvesting system used should be one which causes the least amount of ground disturbance and which minimizes damage to advanced regeneration. Conventional tree-length and full-tree skidding operations should be avoided due to the increased disturbance caused by dragging the trees over the clearcut area. Damage to the site using these systems could be reduced by scheduling the harvesting operation for the winter months when there is sufficient snow cover to protect the advanced regeneration. Subsequent stand development treatments such as thinning and/or herbicide treatment can be used to control the composition and growth of the future stand.

On areas where artificial regeneration will be relied on to reforest an area, the harvesting system used should be one which causes some ground disturbance and effectively removes slash from the cutover area. Light ground disturbance should reduce the amount of natural regeneration present which may compete with the planted stock. Subsequent site preparation treatments and planting will be more effectively accomplished when the slash is removed or dispersed lightly over the cutover areas. A full-tree skidding operation appears to be the most effective harvesting method to accomplish both light ground disturbance and slash removal.

Although the effect that a particular harvesting system has on the establishment and the future development of a stand is an important consideration in the long-term planning of the forest resource, the short-term economic reality of harvesting a volume of wood at the lowest possible price is a prime concern to any forest-based industry. From a production point of view, the logger is often more concerned about the topography of the area, the size and density of the trees, the ground bearing capacity, the availability of harvesting equipment and the interaction ofthe equipment on the site than he is about the long-term biological effects of the operation. With the increasing emphasis on intensive forest management, the choice of a harvesting system for a particular clearcut should involve the biological as well as the economic consequences of the operation.

8. THE FMM SHOULD CONTAIN SPECIFIC REQUIREMENTS SUPPLEMENTED WITH APPROPRIATE GUIDELINES OUTLINING CRITERIA TO BE USED FOR SELECTING CUTOVERS TO BE PLANTED.

It was unfortunate that the post-harvest assessment of the Ormond Lake Study Area was conducted after a portion of the block was scarified and planted. Nevertheless, the entire block was assessed which led to an interesting comparison between the scarified and non-scarified portions of the block. Although this was beyond the original intent of this report, it is interesting to analyse the post-harvest silviculture treatment in relation to the original stand and choice of harvesting system.

Regeneration was very dense on the study area prior to the harvesting operation with an average of 62 550 softwood seedlings per hectare; 97% of which were spruce. Of the regeneration plots assessed, 82% were stocked with softwood seedlings most of which were less than 20 cm in height. The "carpet" of spruce seedlings present before the harvesting operation should have been relied on to produce the future stand. It is not clear when the decision was made to scarify 57% of the block and plant the entire block. Even after the harvesting operation the density, stocking and species composition of the residual natural regeneration seemed sufficient to establish the future stand, with some spot planting. Nevertheless, a management decision was made to scarify a portion of the block and plant.

The FMM identifies three types of silviculture which may be carried out on Crown Lands. Basic Silviculture is the silviculture input specified by DNR with the issuance of a Crown Timber License. Cost of Basic Silviculture is borne by the Crown. Licensee Silviculture refers to silviculture undertaken by the Licensee, at his election and at his cost. Maintenance Silviculture refers to any silvicultural input necessary to maintain the productivity of those harvested areas which have not been designated for Basic or Licensee Silviculture. This Maintenance Silviculture, along with Basic Silviculture, is required to sustain the (1981) allocated harvest for the License.

The specified treatment for the Ormond Lake Study Area was Basic Silviculture. The scarification and subsequent planting was approved and paid for by the Crown. Many questions arise if the correct management decision was made for this block. Since the full-tree harvesting method was used, slash accumulation was absent to light on the majority of the block and there was no need to scarify to disperse slash. Over 97% of the natural regeneration was spruce, a budworm susceptible species at present being planted on many of the Province's cutovers. Although a considerable number of healthy spruce seedlings remained following the harvesting operation, a 60% stocking level may not be attained as indicated by the reduction in the number of plots with regeneration present. However, an acceptable stocking level could be achieved by spot planting rather than the widespread scarifying and planting prescribed for the cutover.

DNR has formulated criteria in the FMM for assessing cutovers selected for Basic Silviculture which establish the minimum level of yield for plantations and areas that are pre-commercially thinned for the year treatment is carried out, and in the fifth year following treatment, to ensure that these cutovers will attain 210 m^3 of merchant- able wood per treated hectare in 40 years. The 40-year period is considered to start immediately after harvesting the original stand. There is, however, no section in the FMM outlining the criteria used for selecting cutover areas to be planted. In the transition to intensive forest management, the choice of silviculture is not a broad one for a License or a Province, but rather a series of stand-by-stand decisions (Baskerville, 1982). As such, each cutover should be assessed on an individual basis, not only prior to but following the harvesting operation so that the proper silvicultural treatments can be prescribed for each area. The FMM should contain specific requirements supplemented with appropriate guidelines outlining criteria to be used for selecting cutovers to be planted. Since the Crown pays for Basic Silviculture, these assessments should be made by DNR staff. The silvicultural dollar should be spent wisely and this will only be done when proper forest management practices are followed.

SOMMAIRE DES RÉSULTATS

Les trois tableaux suivants résument les résultats de l'évaluation des systèmes de récolte dans les six régions à l'étude. Les annexes 1 à 6 présentent des résultats plus détaillés pour chacune de ces régions de même qu'une discussion des résultats et les conclusions atteintes pour chaque emplacement.

Le tableau 1 résume l'information recueillie lors du mesurage effectué avant la récolte. Cette information est évidente en soi ou bien décrite dans les modalités de l'étude; par contre, voici une explication des classifications relatives à la pente et à la densité de branchage : à chaque point de mesurage, on mesurait la pente dans la même direction qu'aurait pris une débusqueuse chargée pour se rendre au bord de la route ou à une jetée préétablie. Une pente défavorable représente le transport hors-route vers le haut de la pente du matériel récolté, tandis qu'une pente favorable représente le transport vers le bas de la pente du matériel récolté. La classification de la densité de branchage sert à décrire la densité et la taille des branches des essences prédominantes.

Le tableau 2 résume le pourcentage de superficie, selon la pente, montrant des traces de machines, un dérangement de la couche organique (humus) et un dérangement de la couche minérale, dans les six régions à l'étude. Ce tableau est complété par une comparaison intéressante, soit entre le dérangement du sol causé par le système de récolte et le dérangement causé par la scarification du site du lac Ormond au moyen de chaînes et de défonceuses.

Le tableau 3 présente un résumé de l'évaluation postérieure à la récolte. La plupart des indications sont évidentes ou bien expliquées dans les modalités de l'étude.

TABLEAU 1. ÉVALUATION ANTÉRIEURE À LA RÉCOLTE

	LAC NORTH LITTLE RIVER	LAC McCORMICK		LAC ORMOND	LAC CRYSTAL	LAC BAYLES	LAC ROCKY
		Secteur sud ouest	Secteur est				
ÉCORÉGION	Highlands du Nouveau Brunswick	Restigouche Bras d'or	Restigouche Bras d'or	Magaguadavic Hillsborough	Magaguadavic Hillsborough	Highlands du Nouveau Brunswick	Magaguadavic Hillsborough
Essences prédominantes; nbre de tiges marchandes par hectare	mélèze épinette 794	mélèze 836	mélèze épinette 667	épinette 1 017	épinette 782	mélèze épinette 853	épinette 1 005
Essences secondaires; nbre de tiges marchandes par hectare	bouleau gris érable rouge 130	épinette 140	érable rouge bouleau gris 87	bouleau gris érable rouge bouleau jaune 205	bouleau gris érable rouge thuya occidental 166	bouleau gris érable rouge 234	érable rouge bouleau gris thuya occidental 125
Nbre de tiges marchandes par hectare	327	1 060	660	311	474	400	494
Volume de résineux marchands	101,0 m^3/ha	104,1 m^3/ha	113,4 m^3/ha	145,8 m^3/ha	101,0 m^3/ha	121,1 m^3/ha	116,6 m^3/ha
Volume de feuillus marchands	10,2 m^3/ha	2,3 m^3/ha	8,6 m^3/ha	32,6 m^3/ha	10,2 m^3/ha	23,2 m^3/ha	12,7 m^3/ha
Classification de la densité de branchage % de la hauteur totale marchande des arbres portant des branches en vie	légère 31 50 %	légère <30 %	légère 31 50 %	légère 31 50 %	légère 31 50 %	touffue 31 50 %	légère 31 50 %
Pente prédominante	favorable	défavorable	défavorable	défavorable	favorable	défavorable	favorable
(0 5	30 %	66 %	68 %	57 %	52 %	42 %	40 %
(6 10	37 %	17 %	16 %	20 %	16 %	24 %	30 %
% du secteur (11 15	23 %	10 %	13 %	16 %	20 %	23 %	13 %
correspondant (16 20	10 %	7 %	3 %	5 %	12 %	6 %	2 %
aux diverses (21 25				1 %			7 %
pentes (26+				1 %		5 %	8 %
Classification do la topographie du terrain	catégorie 1	catégorie 1	catégorie 1	catégorie 2	40 % du secteur catégorie 1 60 % du secteur catégorie 2	catégorie 1	40 % du secteur : catégorie 1 45 % du secteur : categorie 2 15 % du secteur : catégorie 3
Classfication de la résistance du sol	bonne	bonne	bonne	bonne	bonne, quelques endroits mal drainés et bas, couche organique : 100 cm	bonne	68 % du secteur bonne 22 % du secteur moyenne 10 % du secteur : faible
Genre de sol	pierres, limon sableux	pierres, limon sableux	pierres, limon sableux	roches et cailloux recouverts d'une mince couche de limon graveleux	mince couche de limon graveleux	pierres, limon sableux	roches et cailloux recouverts d'une mince couche de matière organique et de limon sableux
Régénération							
Régénération des résineux par hectare	18 700	15 500	23 000	62 150	85 400	152 000	86 200
Peuplement par régénération des résineux	81 %	69 %	88 %	79 %	96 %	97 %	83 %
Régénération des feuillus par hectare	12 000	12 600	20 300	7 590	20 200	20 000	14 900
Peuplement par régénération des feuillus	81 %	55 %	84 %	46 %	58 %	84 %	53 %
% des lotissements où il y a absence de régénération (résineux et feuillus)	6 %	21 %	6 %	7 %	4 %	2 %	5 %
Hauteur moyenne de la régération	<50 cm	<20 cm	<20 cm	<20 cm	<15 cm	<20 cm	<20 cm

TABLEAU 7 DÉRANGEMENT DU SOL

POURCENTAGE DU SECTEUR MONTRANT DES TRACES DE MACHINE, UN DÉRANGEMENT DE LA COUCHE ORGANIQUE ET UN DÉRANGEMENT DE LA COUCHE MINÉRALE

RÉGION À L'ÉTUDE (SYSTÈME DE RÉCOLTE)	DEGRÉ DE DÉRANGEMENT	% DE LA PENTE 0 5	6 10	11 15	16 20	21 25	26+	TOUTES LES PENTES
		% du parterre de coupe						
LAC NORTH LITTLE RIVER	Pourcentage montrant des traces de machine							
	léger		6	6	11			5
	modéré	8	10	14				9
	sévère							6
	Total	8	16	20	11			15
(manuel en bois courts)	Pourcentage montrant un dérangement de la couche organique							
	léger	3	7	11	17			9
	modéré		3					1
	sévère	1	3	0	2			2
	Total	4	13	11	19			12
	Pourcentage montrant un dérangement de la couche minérale							
	léger							
	modéré				3			
	sévère	1						
	Total	1			3			
LAC CRYSTAL	Pourcentage montrant des traces de machine							
	léger	19	23	21	3			18
	modéré	10	6	10				8
	sévère							
	Total	29	29	31	3			26
(mécanique en bois courts)	Pourcentage montrant un dérangement de la couche organique							
	léger	11	8	15	3			10
	modéré	2	10					3
	sévère	18	15	10				14
	Total	31	33	25	3			27
	Pourcentage montrant un dérangement de la couche minérale							
	léger		10	2				2
	modéré							
	sévère							
	Total		10	2				2
LAC ROCKY	Pourcentage montrant des traces de machine							
	léger	19	14	25			4	15
	modéré	8	1			25	25	10
	sévère	9	23		100	25	8	13
	Total	36	40	25	100	25	37	38
(mécanique par arbres entiers/ en bois courts; manuel en bois courts)	Pourcentage montrant un dérangement de la couche organique							
	léger	15	9	9		23	12	14
	modéré	2	4	9	95	1	3	5
	sévère	11	19	10	5	27	14	13
	Total	28	32	28	100	51	29	32
	Pourcentage montrant un dérangement de la couche minérale							
	leger	4	2	0	5	4	8	3
	modéré		2	7			3	2
	sévère	5	16	3		25		8
	Total	9	20	10	5	29	11	13
LAC BAYLES	Pourcentage montrant des traces de machine							
	léger	17	18	34	28		4	21
	modéré	14	9	6	7		2	10
	sévère	6	14	2			2	7
	Total	37	41	42	35		8	38
(mécanique par arbres entiers)	Pourcentage montrant un dérangement de la couche organique							
	léger	10	10	8	12		3	9
	modéré	8	5	3			2	5
	sévère		7	1			2	3
	Total	18	22	12	12		7	17
	Pourcentage montrant un dérangement de la couche minérale							
	léger	2		1			1	1
	modéré	3					2	1
	sévère		7					1
	Total	5	7	1			3	5

RÉGION À L'ÉTUDE (SYSTÈME DE RÉCOLTE)	DEGRÉ DE DÉRANGEMENT	% DE LA PENTE 0 5	6 10	11 15	16 20	21 25	26+	TOUTES LES PENTES
		% du parterre de coupe						
	Pourcentage montrant des traces de machine							
	léger	7	1	21				7
	modéré				50			4
	sévère	4						2
	Total	13	1	21	50			13
LAC McCORMICK (Secteur sud ouest) (manuel en bois courts)	Pourcentage montrant un dérangement de la couche organique							
	léger	4			38			5
	modéré							
	sévère							
	Total	4			38			5
	Pourcentage montrant un dérangement de la couche minérale							
	léger							
	modéré							
	sévère							
	Total							
	Pourcentage montrant des traces de machine							
	léger	5	1	4	8			4
	modéré	8		10	4			6
	sévère		10					2
	Total	13	11	14	12			12
LAC McCORMICK (Secteur est) (manuel en bois courts)	Pourcentage montrant un dérangement de la couche organique							
	léger	8		21	3			8
	modéré	1	11					2
	sévère							
	Total	9	11	21	3			10
	Pourcentage montrant un dérangement de la couche minérale							
	léger	1						1
	modéré							
	sévère							
	Total	1						1
	Pourcentage montrant des traces de machine							
	léger	4	12	6				6
	modéré	2						2
	sévère	7		6				6
	Total	13	12	12				14
LAC ORMOND (Secteur non scarifié) (manuel par arbres entiers pour les résineux et par fûts en tiers pour les feuillus)	Pourcentage montrant un dérangement de la couche organique							
	léger	17	7	24		33	15	17
	modéré	3					18	2
	sévère	3				5		2
	Total	23	7	24		38	33	21
	Pourcentage montrant un dérangement de la couche minérale							
	léger	1				5	3	1
	modéré	2						1
	sévère							
	Total	3				5	3	2
LAC ORMOND	Pourcentage montrant des traces de machine							
	léger							
	modéré							
	sévère			N/A				
(secteur scarifié)	Total							
(manuel par arbres entiers pour les résineux et par fûts en tiers pour les feuillus) (débonceuse)	Pourcentage montrant un dérangement de la couche organique							
	léger	36	40	47	49			40
	modéré	32	29	10	23			27
	sévère	10	15	23	7			13
	Total	78	84	80	79			80
	Pourcentage montrant un dérangement de la couche minérale							
	léger	6	12	7	3			7
	modéré	2		6				2
	sévère			1				1
	Total	8	12	14	3			10

TABLEAU 3 ÉVALUATION POSTÉRIEURE À LA RÉCOLTE

	LAC NORTH LITTLE RIVER	LAC MCCORMICK		LAC ORMOND		LAC CRYSTAL	LAC HAYLES	LAC ROCKY
		Secteur sud ouest	Secteur est	Secteur scarifié	Secteur non scarifié			
SYSTÈME DE RÉCOLTE	Manuel en bois courts	Manuel en bois courts	Manuel en bois courts	manuel par arbres entiers (résineux) manuel par fûts entiers (feuillus)		mécanique en bois courts	mécanique par arbres entiers	mécanique par arbres entiers et en fûts en tiers, manuel en bois courts
SECTEUR RÉCOLTÉ	41 ha	40 ha	89 ha	98 ha	74 ha	88 ha	95 ha	91 ha
ROUTES ET JETÉES SUR LES PARTERRES DE COUPE								
HECTARES OCCUPÉS	1,9 ha	1,3 ha	2,8 ha	8,2 ha		2,0 ha	9,4 ha	15,6 ha
POURCENTAGE OCCUPÉ	4,6 %	3,2 %	3,2 %	4,8 %		2,3 %	9,9 %	17,1 %
POTENTIEL D'ÉROSION								
POURCENTAGE DU PARTERRE DE COUPE (bas	100 %	100 %	97 %	100 %	95 %	96 %	95 %	66 %
SUSCEPTIBLE (moyen			3 %		3 %	4 %	5 %	22 %
D'ÉROSION (élevé					2 %		0	12 %
UTILISATION DES FIBRES								
VOLUME RÉCOLTÉ	6 949 m^3	4 256 m^3	10 860 m^3	25 213 m^3		14 871 m^3	14 505 m^3	11 766 m^3
BOIS MARCHAND GASPILLÉ	3,10 m^3/ha	5,28 m^3/ha	15,83 m^3/ha	4,32 m^3/ha		2,66 m^3/ha	4,63 m^3/ha	4,39 m^3/ha
HAUTEUR MOYENNE DES SOUCHES	17,3 cm	13,1 cm	8,7 cm	9,9 cm		17,3 cm	11,3 cm	16,2 cm
DIAMÈTRE MOYEN DES SOUCHES	19,9 cm	16,2 cm	18,2 cm	21,6 cm		21,9 cm	16,9 cm	18,7 cm
DIAMÈTRE AU FIN BOUT MOYEN DES RÉSINEUX		8,2 cm	8,7 cm	7,8 cm			7,6 cm	7,7 cm
(ET ÉCART)	N C	(6 cm 14 cm)	(6 cm 16 cm)	(6 cm 12 cm)		N C	(4 cm 16 cm)	(4 cm 14 cm)
DIAMÈTRE AU FIN BOUT MOYEN DES FEUILLUS		9,0 cm	10,5 cm	10,7 cm			8,8 cm	9,7 cm
(ET ÉCART)	N C	(6 cm 10 cm)	(6 cm 24 cm)	(4 cm 22 cm)		N C	(4 cm 32 cm)	(6 cm 14 cm)
SUPERFICIE ADDITIONNELLE QUI AURAIT PU ÊTRE RÉCOLTÉE	15 ha			80 ha		16 ha	45 ha	29 ha
VOLUME MARCHAND ADDITIONNEL QUI AURAIT PU ÊTRE RÉCOLTÉ	1 670 m^3			11 600 m^3		1 780 m^3	6 500 m^3	3 750 m^3
TOTAL DES FIBRES MARCHANDES LAISSÉES QUI AURAIENT PU ÊTRE UTILISÉES	1 800 m^3	211 m^3	1 409 m^3	12 309 m^3		2 014 m^3	6 950 m^3	4 150 m^3
ACCUMULATION D'ABATTIS								
POURCENTAGE DU PARTERRE DE COUPE OCCUPÉ PAR UNE (aucune	19 %	15 %	36 %	87 %	57 %	35 %	10 %	49 %
ACCUMULATION (légère	42 %	63 %	32 %	12 %	36 %	43 %	80 %	31 %
D'ABATTIS SELON (modérée	32 %	15 %	22 %	1 %	9 %	9 %	5 %	4 %
LES DIFFÉRENTES (importante CLASSIFICATIONS	7 %	7 %	10 %		1 %	13 %	5 %	16 %
RÉGÉNÉRATION NATURELLE								
RÉGÉNÉRATION DE RÉSINEUX PAR HECTARE	11 000	14 600	17 000	35 000	51 800	52 500	62 000	15 500
POURCENTAGE DE RÉGÉNÉRATION ORIGINALE DE RÉSINEUX	59 %	94 %	52 %	14 %	46 %	49 %	41 %	18 %
PEUPLEMENT PAR RÉGÉNÉRATION DE RÉSINEUX	70 %	69 %	55 %	19 %	57 %	67 %	90 %	43 %
RÉGÉNÉRATION DE FEUILLUS PAR HECTARE	4 300	2 100	1 200	500	200	520	1 000	220
POURCENTAGE DE RÉGÉNÉRATION ORIGINALE DE FEUILLUS	36 %	17 %	6 %	5 %	7 %	3 %	5 %	15 %
PEUPLEMENT PAR RÉGÉNÉRATION DE FEUILLUS	43 %	21 %	17 %	6 %	7 %	11 %	15 %	3 %
POURCENTAGE DES LOTISSEMENTS SANS AUCUNE RÉGÉNÉRATION	20 %	29 %	59 %	76 %	40 %	33 %	10 %	57 %
POTENTIEL DE RÉGÉNÉRATION DU PARTERRE DE COUPE								
POURCENTAGE SELON LE (non limité	100 %	100 %	97 %	90 %	72 %	30 %	98 %	58 %
DÉRANGEMENT (modérément limité			3 %	6 %	19 %	48 %	2 %	27 %
DU SOL COMME (sévèrement limité FACTEUR LIMITATIF				4 %	9 %	22 %		15 %
POURCENTAGE SELON L'ACCUMULATION (non limité	58 %	71 %	67 %	85 %	86 %	29 %	95 %	59 %
D'ABATTIS (modérément limité	23 %	22 %	22 %	10 %	8 %	50 %		19 %
COMME FACTEUR LIMITATIF (sévèrement limité	19 %	7 %	11 %	5 %	6 %	21 %	5 %	22 %
POURCENTAGE SELON L'ÉTAT NATUREL DU (non limité	90 %	50 %	72 %	82 %	81 %	21 %	N.C	23 %
SITE COMME (modérément limité	7 %	33 %	21 %	15 %	9 %	45 %	N.C	42 %
FACTEUR LIMITATIF (sévèrement limité	3 %	17 %	7 %	3 %	8 %	32 %	N.C	35 %
POURCENTAGE SELON LE DÉRANGEMENT DU (non limité	55 %	55 %	52 %	74 %	64 %	13 %	93 %	25 %
SOL, L'ACCUMULATION (modérément limité	23 %	30 %	35 %	17 %	21 %	54 %	2 %	31 %
D'ABATTIS ET L'ÉTAT NATUREL DU SITE (sévèrement limité	22 %	15 %	13 %	9 %	15 %	33 %	5 %	44 %

CONCLUSIONS

À l'exception du système d'exploitation mécanique en bois courts entiers utilisé dans la région du lac Rocky, les systèmes de récolte qu'on a évalués semblent n'avoir causé de dommages étendus sur aucun des sites. Toutefois, le dérangement de sol excessif remarqué au lac Rocky dépend peut-être plus de la piètre qualité du site que du genre de système de récolte employé. Un système d'exploitation manuelle par fûts entiers traditionnel aurait probablement causé des résultats semblables. C'est un système de récolte avec débusquage au-dessus du sol, par exemple un système d'exploitation manuelle en bois courts entiers, qui aurait probablement causé le moins de dommages.

La superficie occupée par les chemins et les jetées dépassait les exigences du manuel d'exploitation forestière (MEF) aussi bien dans les régions du lac Rocky que du lac Bayles. Un système d'exploitation par arbres entiers se caractérise, entre autres, par le fait que les jetées, qu'elles soient situées sur le bord de la route ou dispersées sur le parterre de coupe, occupent généralement une superficie plus grande que celles qu'on retrouve là où s'exerce un système d'exploitation traditionnel par fûts entiers ou en bois courts. On devrait exiger, comme condition préalable à une exploitation par arbres entiers, que plus d'efforts soient consacrés d'avance à l'établissement du nombre et de l'emplacement des jetées, afin que la superficie occupée par ces jetées soit limitée au minimum.

Comme on peut le deviner, le pourcentage de la superficie du parterre de coupe montrant des traces de machine était plus élevé sur les sites où avaient été conduites des activités mécaniques. Il est raisonnable de présumer que plus le nombre de machines utilisées pour l'abattage, le débusquage et les opérations de conversion est élevé, plus ce pourcentage le sera aussi. De même, le pourcentage de superficie où les couches organiques et minérales avaient été dérangées était plus élevé là où avaient été conduites des activités mécaniques. On a également observé une augmentation du dérangement de la couche organique dans les secteurs où des arbres entiers étaient traînés jusqu'aux jetées plutôt que débusqués; cependant, le dérangement de la couche minérale a été minime sur la plupart des sites, à l'exception du parterre de coupe du lac Rocky. Sur la plupart des blocs, le pourcentage de superficie où la couche organique ou minérale avait été dérangée a semblé augmenter avec l'accentuation de la pente, mais non pas la gravité de ce dérangement. Cette tendance n'a pas été observée aux parterres de coupe des lacs Crystal et Bayles. Au lac Crystal, le pourcentage de superficie dérangée de même que la gravité du dérangement n'a pas semblé augmenter avec l'accentuation de la pente. Sur le site du lac Bayles, la superficie de dérangement du sol a semblé diminuer lorsque la pente était supérieure à 20 %.

C'est aux sites des lacs Rocky et Crystal qu'on a retrouvé le plus grand pourcentage de superficie recouverte par une accumulation importante d'abattis. Sur ces deux sites d'exploitation, les opérations de conversion, c'est-à-dire l'ébranchage et l'écimage, ont été effectuées sur le parterre de coupe et non au bord de la route. C'est ensuite sur les sites d'exploitation manuelle en bois courts, puis sur les sites d'exploitation par arbres entiers, qu'on a retrouvé les plus forts pourcentages de superficie recouverte par une accumulation importante d'abattis, que l'abattage ait été effectué mécaniquement ou manuellement, lorsque les opérations de conversion ont été faites sur des jetées situées au bord de la route. L'exploitation par arbres entiers sur les jetées situées au bord de la route peut être avantageuse pour la scarification et la régénération artificielle futures; cependant, ce système produit des rangées d'abattis denses et compactes, et il sera difficile de rendre à la surface sous-jacente sa capacité de production forestière, du moins le temps d'une rotation.

Au cours des activités de récolte, une quantité appréciable de régénération naturelle a été détruite partout dans la région du lac McCormick, sauf dans le secteur sud-ouest. Étant donné que le Manuel d'exploitation forestière n'établit aucune exigence quant à la densité de régénération et au peuplement minimums acceptables pour un parterre de coupe qui vient d'être récolté, il est difficile de conclure si la régénération naturelle postérieure à la récolte de cette surface sera suffisante pour atteindre un certain niveau de productivité et de rendement pendant une période déterminée. Cependant, le MEF spécifie qu'on pourra considérer les surfaces récoltées suffisamment régénérées pour atteindre leurs niveaux de productivité et de rendement précisés lorsque, au bout de cinq ans, elles auront un niveau de peuplement composé d'au moins 60 % d'essences commerciales; en outre, la composition des essences dominantes ne devra pas dépasser de plus de 10 % les unités de forêt prescrites dans l'analyse de l'approvisionnement en bois de chaque titulaire de permis. Par conséquent, l'auteur présume que les parterres de coupe seront suffisamment régénérés si l'évaluation postérieure à la récolte montre un peuplement minimal d'au moins 60 % et une densité minimale de 2 000 tiges par hectare d'épinette et de mélèze en santé, produites par régénération naturelle (dans les six régions à l'étude, les essences prédominantes étaient l'épinette et le mélèze où une combinaison des deux).

Sur tous les parterres de coupe, la densité de régénération naturelle des résineux (épinette et mélèze) était bien au dessus de 2 000 tiges par hectare. Ceci signifie que si on laisse la forêt pousser dans son état naturel, ces parterres de coupe nécessiteront probablement des coupes d'éclaircie dans le futur. Sur les sites du lac Rocky, du lac Ormond et du secteur est du lac McCormick, l'exigence minimale de peuplement de 60 % n'a pas été atteinte. La réduction de la régénération du peuplement de résineux sur les sites des lacs Rocky et Ormond provient de ce que des arbres entiers y ont été halés au cours des opérations de récolte. Là où il y a des traces de halage, les surfaces à régénérer sont dépourvues de toute régénération naturelle. La raison pour laquelle on observe une réduction de la régénération des résineux dans le secteur est du site du lac McCormick n'est pas évidente. Comme il apparaît au tableau 2, le système d'exploitation manuelle en bois courts utilisé sur ce site n'a pas causé un grand dérangement du sol. La seule cause probable de cette absence de régénération peut être attribuée à une exposition soudaine des semis de résineux aux rayons du soleil. La régénération naturelle élevée du peuplement de résineux sur le site du lac Bayles qui a suivi l'exploitation mécanique par arbres entiers pourrait être attribuée au fait que les arbres étaient débusqués sur des jetées au bord de la route, ce qui a éliminé les dommages qu'auraient causé des activités de halage.

C'est aux sites du lac Rocky et du lac Crystal que le potentiel de régénération naturelle est grandement restreint sur le plus grand pourcentage de superficie de parterre de coupe. Sur les deux sites, on a procédé à une récolte mécanique. La condition naturelle des sites semble être le facteur qui a le plus limité le potentiel de régénération. Cependant, le dérangement du sol et l'accumulation d'abattis sur les deux sites ont également constitué des facteurs déterminants. C'est sur le site du lac Bayles que l'on a trouvé le potentiel de régénération le plus élevé, site sur lequel on a effectué la récolte avec le "Koehring Feller Forwarder". Ceci indique qu'un système d'exploitation qui emploie une méthode de débusquage au-dessus du sol et qui accumule les abattis sur des jetées situées au bord de la route, permet d'améliorer le potentiel de régénération naturelle du parterre de coupe, dépendant évidemment de la qualité du site.

En général, on a observé un potentiel d'érosion et d'ensablement peu élevé sur tous les sites, à l'exception de la région du lac Rocky. Un dérangement du sol allant de modéré à important, causé par le travail des machines d'exploitation sur un site de piètre qualité, a contribué à creuser de profondes ornières dans la couche minérale, la rendant ainsi très susceptible à l'érosion.

L'évaluation postérieure à la récolte a indiqué que le bois marchand gaspillé dépassait 3,0 m^3/ha dans toutes les régions à l'étude, à l'exception de celle du lac Crystal. La plus grande partie des produits gaspillés consistait en des arbres de petit diamètre qu'on avait soit laissés sur le parterre de coupe, soit enterrés dans les empilements d'abattis. Dans toutes les régions étudiées, on a respecté le règlement quant à la hauteur maximale des souches, soit 30 centimètres. Le diamètre au fin bout moyen des résineux et des feuillus a indiqué que les résineux marchands étaient mieux utilisés que les feuillus. Le diamètre au fin bout moyen des résineux a également indiqué qu'on en faisait une meilleure utilisation sur les parterres de coupe où les arbres étaient abattus et transformés par des moyens mécaniques.

Sur tous les sites à l'exception de celui du lac McCormick, une planification et un aménagement des blocs auraient permis un rendement appréciable de bois marchand, bois qui est demeuré sur pied entre le bord du parterre de coupe et la zone en bordure du plan d'eau prescrite. À moins que des chemins forestiers traditionnels ne soient construits à travers les parterres de coupe en régénération ou plantés, cette quantité de bois marchand ne sera, en toute probabilité, jamais coupée.

En supposant qu'une supervision appropriée soit exercée, on pourrait adopter la plupart des systèmes de récolte évalués pour l'exploitation des bandes en bordure de plans d'eau, tout en respectant les contraintes environnementales et économiques. Il est évident que certains des systèmes de récolte évalués sont plus efficaces lorsqu'on coupe de larges superficies, puisqu'il y a alors plus d'espace pour manoeuvrer les machines. Par exemple, la coupe sélective d'une zone en bordure d'un plan d'eau serait difficile à effectuer avec les systèmes mécaniques par arbres entiers ou en bois courts. En outre, en utilisant une méthode de coupe sélective, les machines de récolte seraient limitées dans leur trajet. Cependant, on pourrait adapter les systèmes de récolte mécaniques, de même que les autres systèmes évalués, aux zones de récolte en bordure de plans d'eau en effectuant des coupes par bandes larges, des coupes par blocs ou de plus petites coupes à blanc.

Du point de vue productif et économique, il serait avantageux de récolter les zones en bordure des plans d'eau adjacents à des parterres de coupe désignés. On pourrait prévoir les chemins forestiers de manière que les distances de débusquage et de halage soient de la même longueur que celles du parterre de coupe adjacent. De plus, à mesure que progresserait la coupe sur le parterre adjacent, on pourrait étudier les effets du système de récolte employé sur le site pour prédire si, dans certaines conditions environnementales, des effets similaires se feraient sentir dans la zone récoltée en bordure du plan d'eau. La sensibilité de ces zones à la qualité de l'eau de même qu'aux poissons et à la faune requiert une planification et un contrôle appropriés lorsqu'on procède à la récolte de toute partie de cette zone. Le dérangement causé par n'importe lequel des systèmes de récolte évalués doit être maintenu au minimum. Les zones en bordure de plans d'eau contiennent un volume appréciable de bois marchand et ce n'est qu'en procédant à un aménagement forestier intensif et approprié qu'on peut récolter ce bois tout en préservant les avantages que ces zones représentent pour les différentes espèces de poissons et d'animaux de la faune.

ANALYSE DES COÛTS DU BOIS

On a déjà discuté pour chaque région à l'étude, de la pertinence de la récolte des zones en bordure de plans d'eau au moyen des systèmes de récolte évalués. Les conclusions générales auxquelles on en est arrivé sont fondées sur les caractéristiques de chaque zone en bordure d'un plan d'eau de même que sur les limites prévues de chaque système de récolte dans ces zones. Bien qu'on n'ait mené aucune étude de production, on peut tirer des conclusions générales sur la faisabilité économique de la récolte des zones en bordure de plans d'eau en évaluant les effets de cette récolte sur le coût total du bois.

Les zones en bordure de plans d'eau adjacents à des blocs de coupe désignés, dont la largeur est conforme aux directives du **MEF**, ne seraient normalement pas assez larges pour modifier la configuration de la construction des chemins, de sorte que le coût de construction des chemins par unité de bois baisserait légèrement. Bien qu'on ait trouvé que la largeur des zones en bordure de plans d'eau dépassait les directives dans cinq régions étudiées sur six, elles n'étaient quand même pas assez larges pour modifier la configuration de la construction des chemins. Des chemins forestiers supplémentaires seraient nécessaires seulement dans la région du lac Ormond.

Dans toutes les régions étudiées, on devrait s'attendre à une certaine augmentation du coût de débusquage par unité de bois, à moins que le coût ne soit basé sur un taux à la pièce. On suppose alors que la taille des arbres et la qualité du bois sont similaires à celles du parterre de coupe adjacent. L'augmentation du coût de débusquage ou de halage dépendra de la largeur de la zone en bordure du plan d'eau. Dans des zones étroites, l'augmentation du coût de débusquage devrait être relativement minime; cependant, des zones plus larges devraient entraîner une augmentation correspondante dans le coût de débusquage par unité de bois.

Des facteurs spécifiques au site, tels qu'une pente raide, un terrain accidenté et un sol peu résistant, contribueront à réduire la productivité et à augmenter le coût du bois, et ce, dans la mesure où ces facteurs diffèrent de ceux du parterre de coupe adjacent. Sur les surfaces évaluées, il n'a pas semblé y avoir de différence significative entre les caractéristiques des zones en bordure de plans d'eau et les parterres de coupe adjacents, suggérant ainsi que toute augmentation du coût du bois due aux conditions du terrain serait minimale.

Le genre de méthode prescrite dans le cas de bandes en bordure de plans d'eau peut influer sur la productivité. Une coupe sélective peut réduire la production car, pour l'abattage et le débusquage, il faut manoeuvrer autour des arbres sur pied. Cependant, cette supposition tient seulement si la taille moyenne des arbres et la qualité du bois sont équivalentes à celles du parterre de coupe adjacent. Une augmentation de la taille des arbres et un bois de meilleur qualité dans la zone de coupe sélective peuvent annuler les effets de la diminution de production. Des coupes par blocs et par bandes peuvent entraîner une diminution de la productivité, en raison d'une augmentation du retard des machines, qui doivent être manoeuvrées à l'intérieur de limites restreintes; de plus, il devient plus difficile d'accumuler un plein chargement une fois que les débusqueuses ont commencé à manoeuvrer dans les bandes.

L'élément qui contribue le plus à l'augmentation du coût total du bois lorsqu'on parle de la récolte des zones en bordure de plans d'eau adjacents à des parterres de coupe, est la main d'oeuvre additionnelle dont on a besoin pour la planification et la supervision de la coupe. Les limites et contraintes environnementales que la récolte des zones en bordure de plans d'eau doivent respecter demandent une planification et une supervision accrues afin de minimiser les dommages causés au site, tout en maintenant un niveau de production acceptable. On devrait éviter les surfaces où le sol est peu résistant, la pente raide, le terrain accidenté, etc., et les indiquer de telle façon que les opérateurs de machines puissent modifier leur trajet et les éviter, en subissant le moins d'interruption et de retard possible. Là où on effectue des coupes par bandes ou par blocs, on pourrait signaler les surfaces à laisser sur pied par des drapeaux. Dépendant des conditions du site, on pourrait établir des chemins de halage là où le moins de dommage serait infligé, et faire en sorte que les véhicules repassent toujours au même endroit. Cette planification et cette supervision additionnelles peuvent représenter plusieurs fois le coût de la supervision du parterre de coupe adjacent, ce qui ajoute au coût unitaire de bois récolté; cependant, l'effet sur le coût total du bois devrait être assez minime.

RECOMMANDATIONS

1. LES PROCHAINES ÉVALUATIONS DES OPÉRATIONS DE RÉCOLTE DEVRAIENT ÊTRE PLUS DIVERSIFIÉES AFIN D'Y INCLURE UNE VARIÉTÉ DE SYSTÈMES DE RÉCOLTE, RÉPARTIS UNIFORMÉMENT SELON LES PERMIS ET LES ÉCORÉGIONS DE LA PROVINCE.

Il est dommage que les régions choisies pour évaluer les systèmes de récolte étaient seulement groupées sur les terrains de deux titulaires permis de coupe sur des terres de la Couronne, et étaient limitées à seulement trois écorégions précises. Le fait de limiter l'étude à deux permis précis éliminait la chance d'évaluer toute une variété de machines et de systèmes de recolte. Par exemple, on a exclu de cette étude le système manuel d'abattage et de traînage par arbres entiers traditionnel, mais on a évalué le système manuel en bois courts sur deux sites similaires.

On compte sept différentes écorégions au Nouveau-Brunswick, écorégions qui se différencient par le genre de végétation qu'on y retrouve, la composition des essences, la distribution des peuplements, le climat, les formations géologiques, les genres de sol, les réactions aux méthodes de sylviculture, etc. Le fait de restreindre les régions étudiées à seulement trois de ces écorégions n'a pas permis d'évaluer les systèmes de récolte sur une gamme plus large de sites.

Les prochaines évaluations des systèmes de récolte devraient englober une plus grande variété de systèmes et être distribuées plus uniformément selon les permis et les écorégions de la province.

2. LES PROCHAINES ÉVALUATIONS ANTÉRIEURES ET POSTÉRIEURES À LA RÉCOLTE DES SYSTÈMES DE RÉCOLTE DEVRAIENT ÊTRE FAITES PAR LE MÊME PERSONNEL.

Le fait de déterminer la superficie de la couche organique et minérale qui a été dérangée et le nombre de fois qu'une machine a passé sur un endroit précis du parterre de coupe, implique à un jugement subjectif. Bien qu'on ait pu évaluer de façon exacte le pourcentage de superficie et la gravité du dérangement du sol, il a été difficile d'évaluer le nombre de fois qu'une machine avait passé sur certains des terrains à l'intérieur des paramètres fixés dans les modalités de l'étude (une ou deux fois). En fait, l'information recueillie et les résultats formulés tiennent à l'intégrité et à la cohérence de l'équipe d'évaluation. Le temps requis pour faire le relevé antérieur à la récolte, pour observer la récolte et pour faire l'évaluation postérieure à la récolte est tellement long qu'il est difficile de garder le même personnel pour effectuer les trois phases de l'évaluation. Bien que l'on ait pris des notes précises et exactes, le fait d'être familier avec les différents aspects des régions à l'étude aurait été un atout.

3. ON DEVRAIT ÉTABLIR DES LOTS PERMANENTS DE MESURAGE DE SORTE QUE LES EFFETS À LONG TERME DES OPÉRATIONS DE RÉCOLTE PUISSENT ÊTRE SURVEILLÉS.

Les conclusions qu'on a tirées sur les effets des systèmes de récolte sur le potentiel de régénération naturelle dans les régions à l'étude sont fondées sur les données recueillies au cours d'une période d'un an après l'opération de récolte. Évidemment, les facteurs qui déterminent la croissance et le développement de futurs peuplements ne se limitent pas à une telle spéculation subjective. L'étude des nombreux facteurs physiologiques qui influent sur la croissance et la composition du futur peuplement ne s'insérait pas dans l'objectif et l'envergure de ce rapport. La seule façon de surveiller les effets à long terme de ces facteurs serait d'établir des lots permanents de mesurage.

4. LA PLANIFICATION ET L'AMÉNAGEMENT DES BLOCS DE RÉCOLTE DEVRAIENT ÊTRE FONDÉS SUR DES PRINCIPES D'EXPLOITATION FORESTIÈRE SOLIDES ET NON PAS SUR DES CONSIDÉRATIONS GÉOMÉTRIQUES.

L'emplacement des lignes de mesurage et l'évaluation subséquente antérieure à la récolte ont été basés sur l'aménagement des blocs des titulaires de permis, aménagement contenu dans leur plan d'exploitation quinquennal. Dans la plupart des cas, la forme et l'emplacement définitifs du bloc ne reflétaient pas la configuration d'aménagement préliminaire. Il en est résulté que certains des points de mesurage permanents étaient situés en dehors du parterre de coupe et ils ont donc été éliminés de l'évaluation postérieure à la récolte. Du point de vue de l'aménagiste forestier, la dimension, la forme et l'emplacement d'un parterre de coupe dépendent de la quantité de bois endommagé, de l'âge du peuplement et de la composition des essences, de considérations relatives à l'habitat faunique sur un site et en général, des caractéristiques des limites naturelles de même que de la proximité des coupes à blanc adjacentes. Du point de vue du bûcheron, la dimension et la forme d'un parterre de coupe dépendent du genre de sol, des caractéristiques du terrain, du volume du bois marchand ainsi que du système de récolte qui sera utilisé. Comme nous l'avons mentionné dans l'introduction, la quantité de fibres de résineux qu'on peut se procurer est critique, ce qui signifie qu'une planification et un ordonnancement appropriés de la coupe annuelle sont essentiels. Pour atteindre ce but, un aménagement approprié des blocs est la première étape cruciale. La forme et la dimension des coupes à blanc ne devraient pas se fonder sur un dessin géométrique, "sur un rectangle parfait", mais plutôt sur des principes d'exploitation forestière solides.

Tous les parterres de coupe qui ont été évalués sont bordés sur un ou plusieurs côtés par des cours d'eau ou des lacs. La largeur de la zone en bordure du plan d'eau qu'on laisse entre le parterre de coupe et l'eau devrait établir la limite de la coupe à blanc. Dans presque toutes les régions étudiées, un volume appréciable de bois marchand a été laissé sur pied entre la bordure du parterre de coupe et la zone en bordure du plan d'eau. Si on ne construit pas de chemins forestiers additionnels, ou que l'on ne débusque pas ce bois à travers le parterre de coupe déjà planté ou en régénération, ces bandes de bois sur pied isolées ne seront peut-être jamais récoltées.

5. LA LARGEUR DES ZONES EN BORDURE DE PLANS D'EAU DEVRAIT ÊTRE PRESCRITE SUR UNE BASE INDIVIDUELLE EN FONCTION DU COURS D'EAU, ET LA LIMITE DE LA ZONE EN BORDURE DU PLAN D'EAU ADJACENT AU PARTERRE DE COUPE DEVRAIT ÊTRE UTILISÉE COMME LIMITE DU BLOC À RÉCOLTER.

Le MEF n'établit aucune exigence quant à la largeur des zones en bordure de plans d'eau; toutefois, on y trouve des principes directeurs quant à la largeur minimale des zones tampons, soit des largeurs de 15, de 30 et de 60 mètres pour des pentes riveraines respectivement de 0-5 %, de 6-10 % et de plus de 10 % . Ces principes directeurs ont été établis afin de conserver la qualité de l'eau et de protéger l'habitat aquatique. Il se peut que des zones en bordure de plans d'eau plus larges soient exigées en raison de facteurs tels que l'habitat faunique ou des considérations esthétiques et récréatives.

La valeur et les caractéristiques de chaque cours d'eau sont uniques; c'est pourquoi on devrait les traiter sur une base individuelle et qu'il est difficile de prescrire un ensemble de largeurs à appliquer à toutes les zones en bordure de plans d'eau à l'intérieur de la province. Il faudrait inspecter sur le terrain les cours d'eau adjacents aux blocs de récolte ou qui en font partie. L'évaluation des biologistes devrait indiquer la largeur requise en vue de conserver la qualité de l'eau et l'habitat aquatique, de respecter l'habitat faunique et d'évaluer la valeur esthétique et récréative de la zone. L'évaluation du garde forestier devrait indiquer l'âge de la zone, la qualité du bois, la composition des essences; ce dernier devra aussi juger si la topographie du terrain gênera les activités de récolte. L'aménagiste régional des ressources devrait ensuite évaluer la zone en bordure du plan d'eau en fonction de sa valeur économique actuelle et future de même que des avantages qu'elle confère aux espèces aquatiques et fauniques.

On doit prescrire la largeur des zones en bordure de plans d'eau sur une base individuelle afin d'atteindre le compromis optimal entre les préoccupations reliées à la conservation des poissons et de la faune et l'approvisionnement en résineux dont on dispose.

6. BIEN QU'ON AIT DÉPASSÉ LE VOLUME DE BOIS MARCHAND GASPILLÉ ACCEPTABLE DANS CINQ DES SIX RÉGIONS ÉTUDIÉES, LA PRINCIPALE PRÉOCCUPATION DU MINISTÈRE DES RESSOURCES NATURELLES DEVRAIT ÊTRE DE RÉDUIRE LE GASPILLAGE DE BOIS MARCHAND DÛ À UNE PLANIFICATION ET À UN AMÉNAGEMENT IMPROPRES DES BLOCS.

La Loi sur les terres et forêts de la Couronne interdit les pratiques de coupe génératrices de gaspillage sur les terres de la Couronne, dont les suivantes :

1) couper un arbre en laissant une souche qui mesure plus de 30 centimètres de hauteur;

2) ne pas amener au bord de la route tout bois ou bûche à valeur marchande, qui avait été indentifié dans le plan d'exploitation comme essence à être coupé, que ce bois ou cette bûche soit coupé, non coupé, encroué ou poussé avec un bouteur;

3) parer le pied de tout bois marchand qui n'est pas considéré comme du bois de rebut en vertu de la Loi sur les mesureurs de bois;

4) couper ou endommager tout arbre qui n'est pas inclus dans le plan d'exploitation.

Une bûche marchande signifie tout produit forestier de base qui a une longueur de 2,44 mètres et dont le diamètre au fin bout est de 8,0 centimètres écorce comprise. Un arbre marchand signifie tout arbre qui contient au moins une bûche marchande.

Le ministère des Ressources naturelles (MRN) reconnaît qu'une certaine quantité de bois marchand demeurera sur le bloc après une opération de récolte. Plusieurs facteurs peuvent contribuer à une telle situation, dont un manque de supervision sur le site, le système de récolte et la méthode de coupe utilisés, la composition des essences, la condition et la taille des arbres de même que l'état du site quant à la topographie du terrain et la résistance du sol. Le ministère tolère qu'on laisse 3,0 m^3/ha de bois marchand sur un bloc et l'aménagiste régional des ressources peut demander au titulaire de permis de faire un rapport sur le volume de bois marchand gaspillé pour toute récolte effectuée sur les terres couvertes par son permis. C'est l'aménagiste régional des ressources qui décide s'il y a lieu d'imposer des pénalités lorsque le volume toléré de 3,0 m^3/ha est dépassé sur un bloc.

L'analyse du gaspillage effectuée dans le cadre de cette étude montre que la quantité de bois marchand demeurée sur un bloc après la récolte dépassait 3,0 m^3/ha sur cinq des six blocs évalués. La plus grande partie du bois gaspillé (72 % pour les six blocs) se présentait sous forme d'arbres entiers, qui mesuraient en général 10 centimètres de diamètre à hauteur d'homme. Il ne semble pas y avoir de corrélation entre le genre de système de récolte utilisé et la quantité de bois marchand gaspillé demeurée sur un bloc donné.

Bien que l'on ait dépassé le volume de bois marchand gaspillé toléré sur cinq des six blocs, il serait présomptueux de projeter ce même pourcentage pour tous les blocs récoltés sur les terres de la Couronne. Cependant, un tel résultat souligne la nécessité pour le ministère d'enquêter sur un plus grand nombre de parterres de coupe afin de s'assurer que l'exigence relative au bois marchand gaspillé n'est pas dépassée dans une aussi grande mesure que dans les régions à l'étude.

Bien que le fait de réduire le volume de bois marchand gaspillé sur un parterre de coupe semble une mesure logique pour augmenter l'utilisation totale, le volume de bois marchand abandonné dans les régions à l'étude n'était qu'une goutte d'eau comparé au volume de bois resté sur pied à cause d'un mauvais aménagement de bloc. Si on considère le volume total qui aurait pu être récolté sur les six parterres de coupe, seulement 4 % de ce volume représente du bois marchand directement gaspillé à cause de l'activité de récolte, tandis que 29 % de ce volume a été laissé sur pied entre le bord du parterre de coupe et la zone en bordure du plan d'eau approuvée. C'est donc dire que les cimes et les bûches, les arbres de petit diamètre, les pattes reséquées, les longrines et les billes laissés dans les parterres de coupe ne pèsent pas lourd lorsqu'on considère la situation dans son ensemble. On peut imposer des pénalités pour dissuader le gaspillage du bois marchand dans les parterres de coupe, mais quelle est la pénalité pour un mauvais aménagement de bloc, à part celle de refléter la faiblesse des méthodes de gestion forestière?

7. LES DÉCISIONS RELATIVES À L'AMÉNAGEMENT ET AU DÉVELOPPEMENT FUTURS D'UN PARTERRE DE COUPE DEVRAIENT ÊTRE PRISES AVANT L'OPÉRATION DE RÉCOLTE.

Dans cette province, il existe une dissociation historique entre la phase de récolte et la phase de sylviculture de la gestion d'un peuplement forestier. Jadis, le coût auquel était produit l'unité de bois constituait le facteur déterminant quant à la façon et au moment d'effectuer la récolte d'un peuplement. On percevait la sylviculture comme un remède postérieur à la récolte, sans rapport avec cette dernière, en vue de s'assurer un volume de bois marchand à une date future. Cependant, la province ayant fait la transition à une exploitation forestière intense, l'industrie forestière en est venue à accepter que l'ordonnancement des blocs de récolte, le choix des systèmes de récolte, les méthodes de coupe, la préparation des sites, la plantation, l'éclaircie, etc., sont tous des outils de sylviculture qui permettent une bonne gestion des ressources forestières. Un des objectifs fondamentaux d'une bonne exploitation forestière est de comprendre la relation entre ces facteurs et le maintien et l'amélioration des peuplements forestiers.

Le fait d'effectuer des coupes à blanc dans les peuplements de résineux est une technique de sylviculture acceptée dans cette province, puisque la plupart des peuplements de résineux sont trop âgés et susceptibles d'être endommagés par la tordeuse du bourgeon de l'épinette.

Deux solutions s'offrent à nous pour aménager un peuplement, une fois qu'il a été coupé à blanc : compter sur la régénération naturelle, ou bien procéder à une régénération artificielle. Quelle que soit la décision quant à l'aménagement et au développement futurs d'un parterre de coupe, elle devrait être prise avant la récolte. Dans les zones où l'on comptera sur la régénération naturelle pour reconstituer la forêt, on devrait employer le système de récolte qui cause le moins de dérangement du sol et qui minimise les dommages faits à la régénération préexistante. On devrait éviter l'exploitation traditionnelle par fûts entiers ou par arbres entiers puisque le fait de haler les arbres sur la zone coupée à blanc augmente le dérangement du sol. Les dommages causés par ces méthodes pourraient être réduits en effectuant la récolte durant les mois d'hiver, lorsque la couche de neige est suffisante pour protéger la régénération préexistante. On peut ensuite procéder à l'éclaircie ou au traitement à l'herbicide pour contrôler la composition et la croissance du futur peuplement.

Dans les zones où l'on comptera sur une régénération artificielle pour reconstituer la forêt, on devrait employer un système de récolte qui cause un certain dérangement du sol et enlève efficacement les abattis du parterre de coupe. Un léger dérangement du sol devrait réduire la quantité de régénération naturelle présente, régénération qui pourrait nuire aux plantations. La préparation et la plantation subséquentes d'un site donneront de meilleurs résultats si les abattis sont enlevés ou légèrement dispersés sur le parterre de coupe. Il semble que le débusquage par arbres entiers soit la méthode de récolte la plus efficace pour déranger légèrement le sol et retirer les abattis.

Bien que l'effet d'un système de récolte donné sur l'aménagement et le développement futurs d'un peuplement soit une considération importante dans la planification à long terme des ressources forestières, la réalité économique à court terme, soit de récolter un volume de bois au meilleur prix possible, demeure une préoccupation majeure de l'industrie forestière. Du point de vue de la production, le bûcheron est plus souvent préoccupé par la topographie de la région, la taille et la densité des arbres, la résistance du sol, la disponibilité de l'équipement de récolte et l'interaction des équipements sur le site, que par les effets biologiques à long terme de l'exploitation. Un accent de plus en plus grand étant mis sur l'exploitation forestière intensive, le choix d'un système de récolte pour un parterre de coupe donné devrait tenir compte aussi bien des conséquences biologiques qu'économiques de l'exploitation.

8. LE MEF DEVRAIT CONTENIR DES EXIGENCES PRÉCISES ACCOMPAGNÉES DES PRINCIPES DIRECTEURS APPROPRIÉS QUANT AUX CRITÈRES À UTILISER DANS LA SÉLECTION DES PARTERRES DE COUPE DEVANT ÊTRE PLANTÉS.

Il est malheureux que l'évaluation postérieure à la récolte de la région du lac Ormond ait été faite après la scarification et la plantation d'une partie du bloc. Néanmoins, le bloc au complet a été évalué, ce qui nous a permis de faire une comparaison intéressante entre la partie scarifiée et la partie non scarifiée. Même si une telle comparaison dépassait le cadre de ce rapport, il est intéressant d'analyser le traitement de sylviculture postérieur à la récolte en fonction du peuplement original et du choix du système de récolte.

Avant la récolte, la région étudiée présentait une régénération très dense, avec une moyenne de 62 550 semis de résineux par hectare. 97 % de ces semis était constitués d'épinette; 82 % des lotissements de régénération qui ont été évalués étaient peuplés de semis de résineux, dont la plupart avait moins de 20 centimètres de hauteur. On aurait dû compter sur le "tapis" de semis d'épinette existant avant la récolte pour produire le futur peuplement. On ne sait pas exactement quand la décision de scarifier 57 % du bloc et de le planter au complet a été prise. Même après la récolte, la densité du peuplement et la composition des essences de la régénération naturelle restante semblaient suffisantes pour assurer le peuplement futur; seule une plantation sur placeaux était nécessaire. Néanmoins, on a décidé, au niveau de la gestion, de scarifier une partie du bloc et de le planter.

Le MRF reconnaît trois genres de sylviculture peuvant être pratiqués sur les terres de la Couronne. La sylviculture de base représente les opérations sylvicoles précisées par le ministère des Ressources naturelles lorsque ce dernier délivre un permis de coupe du bois sur des terres de la Couronne. Le coût de la sylviculture de base est défrayé par la Couronne. La sylviculture d'exploitation représente les opérations sylvicoles entreprises par le titulaire de permis, à son choix et à ses frais. La sylviculture d'entretien désigne toute opération sylvicole nécessaire pour maintenir la productivité des secteurs récoltés non soumis à une sylviculture de base ou d'exploitation. Comme la sylviculture de base, la sylviculture d'entretien sert à soutenir la récolte allouée (1981) en vertu du permis.

Dans le cas de la région du lac Ormond, le traitement précisé en était un de sylviculture de base. La scarification et la plantation subséquentes étaient donc approuvées et payées par la Couronne. On peut se poser des questions sur la pertinence de la décision prise pour ce bloc. Étant donné qu'on a utilisé la méthode de récolte par arbres entiers, l'accumulation d'abattis était nulle ou légère sur la plus grande partie du bloc, et il n'était pas nécessaire de scarifier pour disperser les abattis. Plus de 97 % de la régénération naturelle était constituée d'épinette, une essence susceptible à la tordeuse du bourgeon et qui est actuellement plantée sur de nombreux parterres de coupe de la province. Bien qu'un nombre appréciable de semis d'épinette en santé soit demeuré sur le parterre après la récolte, il n'est pas certain que le niveau de peuplement de 60 % soit atteint, ainsi que le montrait la réduction du nombre de lotissements où une régénération était présente. Cependant, on aurait pu atteindre un niveau de peuplement acceptable en procédant à une plantation par placeaux plutôt qu'en effectuant la scarification et la plantation étendues prescrites pour le parterre de coupe.

Le ministère des Ressources naturelles a formulé des critères qu'on retrouve dans le MEF, relativement à l'évaluation des parterres de coupe sélectionnés en vue d'une sylviculture de base; ces critères fixent le niveau minimum de rendement des plantations et des secteurs éclaircis précommercialement durant l'année où est effectué le traitement, et cinq ans après le traitement, afin de s'assurer que le rendement de ces parterres de coupe atteigne 210 m^3 de bois marchand par hectare traité dans 40 ans. On compte la période de 40 ans à partir de la récolte du peuplement original. Cependant, aucune section du MEF n'expose les critères utilisés dans la sélection des parterres de coupe devant être plantés. Dans une période de transition à une gestion forestière intensive, le choix d'une méthode de sylviculture n'est pas unique pour l'ensemble des permis et de la province, mais consiste plutôt en une série de décisions prises pour chaque peuplement (Baskerville, 1982). Cela signifie que chaque parterre de coupe devrait être évalué sur une base individuelle, non seulement avant mais après l'opération de récolte, de façon que les traitements de sylviculture appropriés puissent être prescrits pour chaque secteur. Le MEF devrait contenir des exigences précises, accompagnés des principes directeurs appropriés, qui exposent les critères à utiliser pour la sélection du parterre de coupe à planter. Étant donné que la Couronne paye les frais engagés dans le cadre de la sylviculture de base, c'est le personnel du ministère des Ressources naturelles qui devrait faire les évaluations. On devrait dépenser judicieusement les dollars alloués à la sylviculture, et ceci deviendra réalité seulement lorsqu'on suivra des pratiques de gestion forestière ad hoc.

LITERATURE CITED

Baskerville, G., 1982. Strategic planning in the transition to forest management, pp. 17-20. In: Reprint of papers presented at the 63rd annual meeting of the Woodlands Section, C.P.P.A., 1982.

Loucks, O. L., 1961. A forest classification for the Maritime Provinces. Forest Research Branch, Department of Forestry, Fredericton, N.B. Cat. No. FO-42-4362.

LITERATURE REVIEWED

Baskerville, G., 1982. Strategic planning in the transition to forest management, pp. 17-20. In: Reprint of papers presented at the 63rd annual meeting of the Woodlands Section, C.P.P.A., 1982.

Loucks, O. L., 1961. A forest classification for the Maritime Provinces. Forest Research Branch, Department of Forestry, Fredericton, N.B. Cat. No. FO-42-4362.

Mellgren, P. G., 1980. Terrain classification for Canadian Forestry. Forest Engineering Research Institute of Canada, for PPRIC, pp. 13.

Moore, G. C., and G. S. Henley, 1984. Management of watercourse buffer zones. N.B. Department of Natural Resources, Forest Utilization Branch, Fredericton, N.B. Cat. No. ISBN 0-88838-785-7.

Province of New Brunswick, 1984. Forest Management Manual for Crown Lands. N.B. Department of Natural Resources, Forest Management Branch, Fredericton, N.B.

Smith, B. M. and D. A. Carlin, 1979. Point sampling cruising instructions. N. B. Department of Natural Resources, Forest Management Branch, Fredericton, N.B.

Wilton, W. C. and W. P. Duffett, 1980. Whole tree chipping for hogged fuel in Newfoundland. Newfoundland Forest Research Centre, St. John's, Nfld. Environment Canada, Forest Service Information Report N-X-186, pp. 55.

APPENDIX I

NORTH LITTLE RIVER LAKE STUDY AREA

An Evaluation of the Manual/Short-wood Harvesting System

NORTH LITTLE RIVER LAKE STUDY AREA

Description of Study Area

The North Little River Lake study area was located northwest of Newcastle in the New Brunswick Highlands ecoregion (Loucks, O.L. 1961). Balsam fir (Abies balsamea (L.) Mill.) and spruce (Picea spp.) were the predominant tree species on the study area with 794 merchantable stems per hectare and was intermixed with 130 merchantable stems per hectare of white birch (Betula papyrifera Marsh.) and red maple (Acer rubrum L.).[1] There were approximately 327 unmerchantable stems per hectare of small diameter trees and larger cull trees. There were 101.0 m^3/ha of merchantable softwood and 10.2 m^3/ha of merchantable hardwood on the block. Branchiness was generally light with 31-50% of the merchantable tree height containing live branches. Slope on the block was predominantly favorable with 30% of the area in the 0-5% range, 37% in the 6-10% range, 23% in the 11-15% range and 10% in the 16-20% range. The entire block was of Class I ground roughness and the ground bearing capacity was good for the entire area. The soils in this ecoregion are generally stony, sandy loams (Loucks, O.L. 1961). Regeneration was dense in the study area with an average of 18 700 softwood seedlings and 12 000 hardwood seedlings per hectare. Of the regeneration plots assessed 6% had neither softwood nor hardwood regeneration; 81% had softwood seedlings and 81% had hardwood seedlings. Most seedlings were less than 50 cm in height.

Harvest

The entire area was clearcut of all merchantable species by a manual/short-wood system. Trees were felled and bucked into veneer and pulpwood at the stump then forwarded by a short-wood forwarder to roadside. Harvesting took place in the summer and fall with weather conditions being good, both prior to and during the harvesting phase.

Results

Roads and Landings

Roads and bulldozed landings occupied 4.6% (1.9 ha) of the 41 ha block; which is within the requirements of the

---

[1] A merchantable stem is defined as a commercial species of tree measuring greater than 8.0 cm (inside bark) at a point greater than 2.44 m but equal to or less than 2.60 m above the allowable stump height of 30 cm.

FMM. There was approximately 1.15 km of road on the block and road plus bulldozed landings averaged 16.4 m in width.

Ground Disturbance on the Unbulldozed Cutover

The percentage of unbulldozed cutover area occupied by machine tracks and the percentage of area with organic and mineral layer disturbance are shown by slope class in Table 1. The percentage of area occupied by machine travel averaged 15% and increased for slopes up to 16%, however a decrease appeared to occur at slopes greater than 15%. Organic layer disturbance occurred on 12% of the area and increased with increased slope. Mineral layer disturbance

Table 1. Percentage of area occupied by machine tracks, organic layer disturbance and mineral layer disturbance on the North Little River Lake Study Area.

Degree of Disturbance	Slope % 0-5	6-10	11-15	16-20	21+	All Slopes
	% of cutover area					
PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS						
- Light	0	6	6	11	---	5
- Moderate	8	10	14	---	---	9
- Heavy	---	---	---	---	---	6
Total	8	16	20	11	---	15
PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE						
- Light	3	7	13	17	---	9
- Moderate	---	3	---	---	---	1
- Heavy	1	3	---	2	---	2
Total	4	13	13	19	---	12
PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE						
- Light	---	---	---	---	---	---
- Moderate	---	---	---	3	---	---
- Heavy	1	---	---	---	---	---
Total	1	---	---	3	---	1

occurred on 1% of the area and decreased for slopes up to 16%, there was an increase on slopes above 15%. Although the area occupied by machine travel decreased for slopes greater than 15%, the area of organic and mineral layer disturbance showed an increase in the level of disturbance. This would indicate that disturbance caused by the shortwood harvesting system did indeed increase with steeper slopes.

Slash Dispersal on the Unbulldozed Cutover

Slash on the unbulldozed cutover was absent on 19%, light on 42%, moderate on 32% and heavy on 7% of the unbulldozed area. Slash was distributed in rows at right angles to the bulldozed access road and in the direction that the forwarding machines travelled. Slash depth in the heavy classification was often greater than 1.0 m.

Post-Harvest Regeneration on the Unbulldozed Cutover

Following the harvesting operation it was estimated that there were 11 000 softwood seedlings and 4 300 hardwood seedlings per hectare in an undamaged or only slightly damaged condition, or 59% of the original softwood seedlings and 36% of the original hardwood seedlings. There were softwood seedlings in 70% and hardwood seedlings in 43% of the sample plots following the harvesting operation.

Regeneration Potential on the Unbulldozed Cutover

Regeneration potential was assessed on a plot-by-plot basis in the unbulldozed cutover. The limiting factors considered were soil disturbance, slash accumulation and the natural condition of the site. Using only soil disturbance as the limiting factor, regeneration potential was estimated to be not limited in 100% of the plots. Using only slash accumulation as the limiting factor, regeneration potential was estimated to be not limited in 58%, moderately limited in 22% and severely limited in 19% of the plots. Using only the natural condition of the site as the limiting factor, regeneration potential was estimated to be not limited in 90%, moderately limited in 7% and severely limited in 3% of the plots.

The cutover area in the severely limited regeneration potential classification occurred under deep slash piles due to several trees being delimbed and/or topped on that same location. Using soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors,

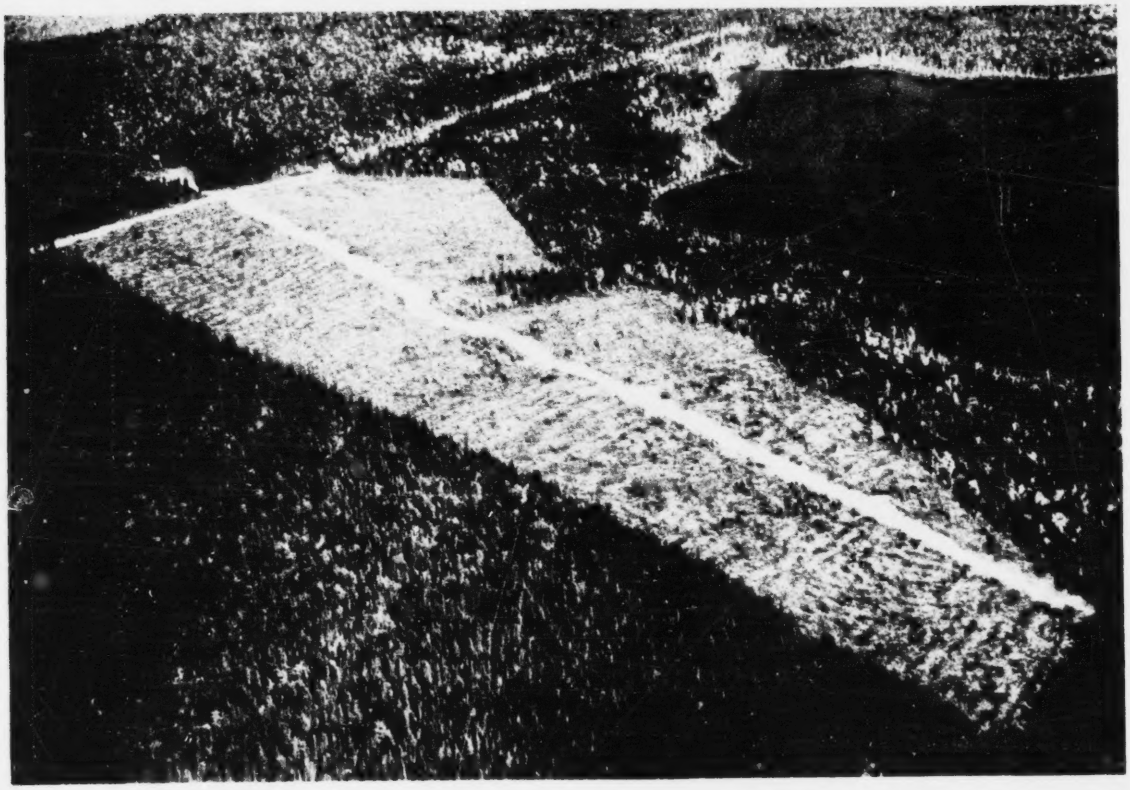


Figure 2.
North Little River Lake Study Area

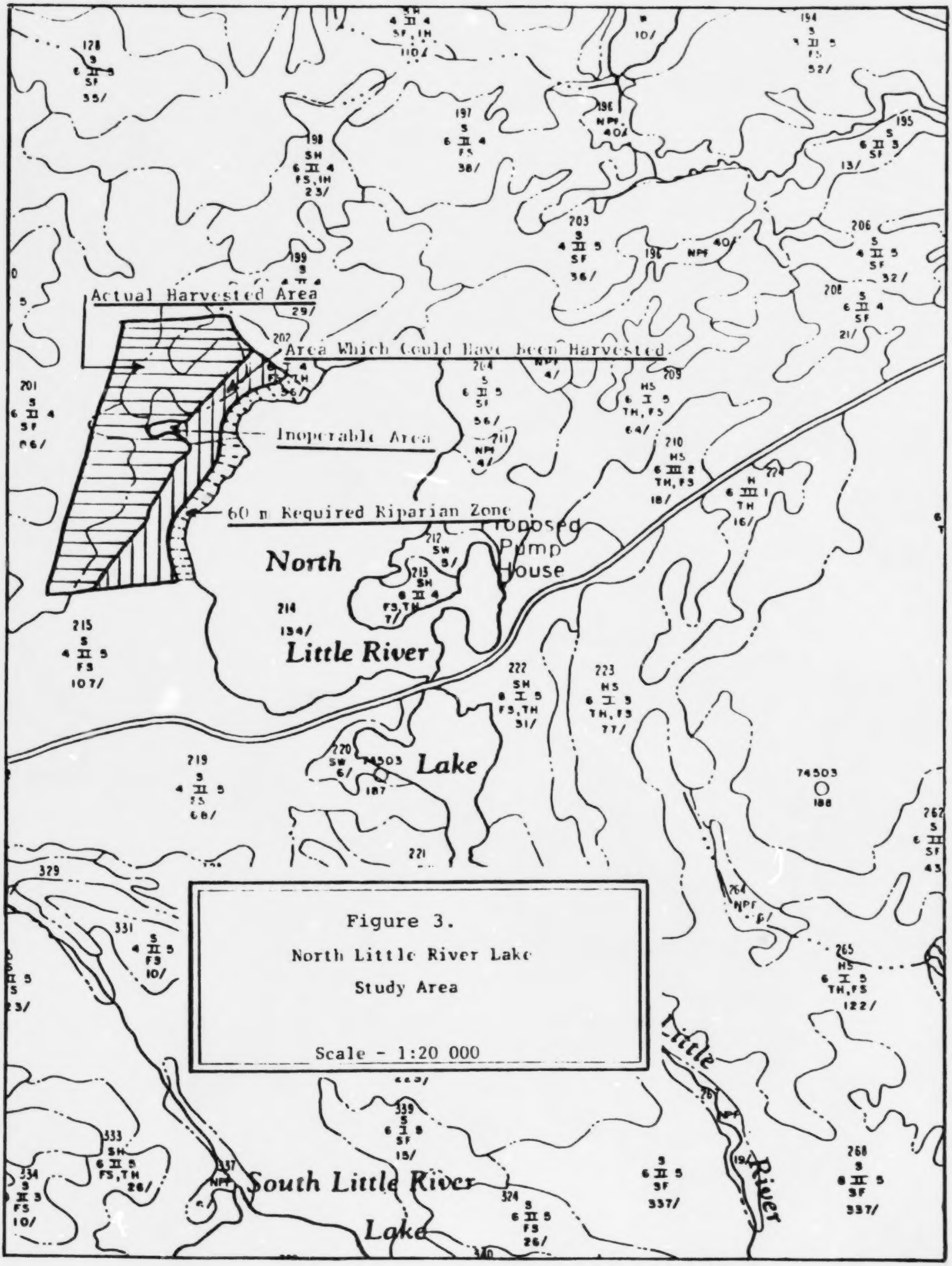


Figure 3.
North Little River Lake
Study Area

Scale - 1:20 000

regeneration potential was estimated to be not limited in 55%, moderately limited in 23% and severely limited in 22% of the plots.

Erosion Potential on the Unbulldozed Cutover

Erosion potential, using the subjective classification outlined on page 8, was assessed on a plot-by-plot basis only on the unbulldozed cutover. Erosion potential was estimated to be low on 100% of the plots.

Fibre Utilization

The volume of merchantable waste averaged 3.10 m^3/ha. The majority of this waste was found in long butts which averaged 1.65 m^3/ha, waste in tops and bolts averaged 0.86 m^3/ha, waste in full-trees averaged 0.49 m^3/ha and waste in skids and logs averaged 0.10 m^3/ha. It is apparent from these results that the decisions the chainsaw operator made during felling and bucking resulted in much of the waste left on the block. Total merchantable waste was calculated to be 127.1 m^3 or approximately 1.8% of the 6 949 m^3 harvested on the block.[2]

The average stump height on the block was 17.3 cm and the average stump diameter was 19.9 cm. The average height to diameter ratio was 0.92.

The FMM states that the minimum horizontal buffer strip width for watercourse bank slopes greater than 10% should be 60 m. The actual riparian strip left between the cut and North Little River Lake, however, averaged 206 m. This extra width of reserve occupied 15 ha which would have yielded an additional 1 670 m^3 of wood.

In total the block could have yielded an additional 1 800 m^3 of wood by eliminating merchantable waste and using a riparian strip 60 m in width.

---

[2] The 6 949 m^3 is the actual volume of all primary forest products scaled on the block.

Discussion

Roads and Landings

Roads and bulldozed landings occupied 4.6% of the block area which is within the allowable limit of 5% as outlined in the FMM. The bulldozed landings were an extended width of the logging road allowing for the merchantable wood, in short-wood form, to be piled along the road. The average width of the bulldozed area was 16.4 m which is within the 20 m permitted in the FMM.

Ground Disturbance on the Unbulldozed Cutover

The apparent decrease in area occupied by machine tracks on the unbulldozed cutover occurred on slopes greater than 15%. The forwarding machines, where possible, avoided the steeper slopes for machine manoeuverability and safety reasons, however, the 11% of the area occupied by machine tracks in the 16-20% range suggests that the forwarding machine could manoeuver on steep slopes when required. Most of the soil damage was caused by wheel tracks with only minimal damage caused by the forwarders knocking over unmerchantable trees. It was often difficult to estimate the area occupied by machine tracks especially on areas where the short-wood forwarders only made one pass. The 15% of the area occupied by machine tracks could be unrealistically low for this type of harvesting system.

Approximately 80% of the area occupied by machine tracks did cause some disturbance to the organic layer. However, most of the damage was in the light classification. Areas where there was medium to heavy organic layer disturbance occurred where the forwarding machines made more than two passes. Organic layer disturbance did appear to increase with increasing slopes, however, the severity of this disturbance did not seem to increase. This suggests that severity of organic layer disturbance is probably more dependent on the number of machine passes than the slope on which the forwarding machines are operating.

The proportion of area occupied by mineral layer disturbance was minimal with only 1% of the area affected. The disturbance was in the medium to heavy classification and was the result of two or more machine passes. Mineral layer disturbance did increase with increasing slope, however, the severity of this disturbance did not.

The severity of organic and mineral layer disturbance appears to be more affected by the number of machine passes rather than slope and for this reason any attempt to reduce the severity of this ground disturbance should be directed at reducing the number of passes the forwarding machines make over the same area.

Slash Disposal on the Unbulldozed Cutover

The manual/short-wood harvesting system employed on this block resulted in continuous strips of slash being laid down at right angles to the logging road to the full width of the block. This resulted in 32% of the unbulldozed area in the moderate slash accumulation classification and 6% in the heavy classification. As a result the regeneration potential was severely limited on 19% of the area. This is significant in that regeneration and subsequent growth on 8 ha of the area could be restricted. An effective form of slash disposal must be used, not only to increase the natural regeneration potential but also to facilitate any reforestation efforts that may be required.

Post-Harvest Regeneration on the Unbulldozed Cutover

There was a considerable reduction in the number of healthy seedlings on the block following harvest, however, substantial numbers still remain. The number of plots with softwood regeneration dropped from 81% before harvest to 70% after harvest. The short-term effect of the heavy rows of slash present may be to retard the growth of the tolerant softwood regeneration present under the slash. However, in the long-term this slash may provide an effective filter layer so that the tolerant softwood seedlings do not become scorched by the direct exposure to the sunlight. Softwood tops contained in these slash piles may also provide an immediate seed source. Most of the damage to the advanced regeneration on the block was caused by the forwarder's wheels. The uniform distribution of the forwarding machine over the block is a characteristic of a manual/short-wood harvesting operation and it is unlikely that an effective reduction in the area occupied by the wheel tracks can be achieved. Harvesting this area in the winter when there is an adequate cushion of snow on the ground may reduce the damage to the advance regeneration.

Regeneration Potential on the Unbulldozed Cutover

Soil disturbance had no detrimental effect on the ability of the area to be regenerated. Regeneration potential, because of the natural condition of the site, was severely limited on 3% of the area. This was due mainly to heavy raspberry (Rubus spp.) growth present immediately following the harvesting operation. Using soil, slash accumulation and/or the natural condition of the site as the limiting factors, regeneration potential was estimated to be severely limited on 22% of the area. This area, which represents approximately 9 ha, may be incapable of producing a vigorous stand of timber within one rotation period unless some form of silviculture treatment is initiated.

Erosion Potential on the Unbulldozed Cutover

With this particular combination of machinery and site, erosion and siltation would not be expected to be a problem, as 100% of the area was classified as having low erosion potential. The site was well-drained, had good ground bearing capacity and the slopes did not exceed 20%. On a poorer site with a bearing capacity not capable of supporting more than two passes of the forwarding machine, the ground disturbance could create a high degree of erosion and siltation potential. Erosion potential could also increase on areas with slopes greater than 20% especially when the forwarders make several passes over the same area.

Fibre Utilization

Merchantable waste volume averaged 3.10 m^3/ha which is slightly in excess of the 3.0 m^3/ha allowable in the FMM. Most of this merchantable waste was in the form of long butts. This is the direct result of the chainsaw operator making the wrong decision while bucking the trees to length at the stump. The feller in a trail-cut operation is paid on the amount of merchantable product he produces, some butt logs or sections containing stain or rot are bucked from the tree and discarded. The feller sometimes overestimates the length of unmerchantable wood and removes a section that contains little or no rot thus resulting in waste. Premature topping and not harvesting small diameter merchantable trees also resulted in some waste being left on the block.

Stumps were generally cut low resulting in little or no waste. The higher stumps generally occurred in the larger diameter classes but in most cases these stump heights were less than the 30 cm requirement as outlined in the FMM.

An additional 1 6700 m^3 of fibre could have been harvested if the area between the 60 m buffer strip and the actual cut was harvested. This 15 ha area amounted to 36% of the area that was actually harvested. The maximum slope on this unharvested area was slightly greater than the maximum slope encountered on the harvested section, however, this should not have restricted the operability of this area with this type of harvesting system. Other than slope, there appears to have been no other site-related reason for not harvesting this area. With the remaining timber being located in a 200 m wide strip along approximately 1.15 km of lakeshore it is unlikely that this timber will ever be harvested.

Suitability to Existing Forest Conditions

The manual/short-wood harvesting operation appeared to be well suited to this particular area. The site was well-drained upland site with very few springs and good ground bearing capacity. Mineral layer disturbance was minimal and the forwarding machines were capable of operating on slopes up to 20% with little if any increase in soil disturbance. Although there were considerably fewer seedlings present following the harvesting operations, the number of healthy seedlings remained in adequate numbers. The heavy rows of slash will provide a barrier to artificial reforestation efforts and some form of slash disposal may be required if the area warrants artificial reforestation.

Suitability for Harvesting Environmentally Sensitive Areas

Based on field observations and the results of the assessments made on this particular harvest block it is the author's opinion that the manual/short-wood system could be used to harvest, within acceptable environmental limitations, wood in riparian strips and deer yards.

The manual/short-wood system as the name implies is best suited for harvesting in strips, patches or larger clearcuts. Selective cutting in riparian zones would be extremely limited with this type of harvesting system. It is conceivable however that selective cutting could take place in riparian zones having a high percentage of sawlog material and few stems per hectare of small diameter trees. The orientation of the cut strips using this harvesting system would normally be at right angles to the watercourse regardless of the width of the riparian zone. Each trail cutter normally works in strips 20 m to 30 m in width; however, narrower strips could be cut provided there is sufficient room for the forwarders to manoeuver. The length of the trail into the riparian zones will depend on the characteristics of the site, such as slope, ground roughness and ground bearing capacity.

The short-wood forwarders appear to have had little difficulty in negotiating slopes up to 20% provided that the ground roughness and bearing strength of the soil was such that few obstacles impeded the machines manoeuverability. Short-wood forwarders would be severely limited on slopes greater than 20% and on sites with a high degree of ground roughness. Areas of poor ground strength should be avoided as the ground strength will not support the weight of the forwarders and severe ground disturbance will result.

Conclusions

The manual/short-wood system did not appear to cause any major problem on this particular site.

The area occupied by roads and landings was 4.6% which is within the requirements outlined in the FMM.

Machine tracks occupied 15% and organic and mineral layer disturbance occupied 12% and 1% respectively of the unbulldozed area. The amount of soil disturbance appeared to increase with increasing slope; however, the severity of this disturbance did not.

Slash accumulation was absent on 19%, light on 42%, moderate on 32% and heavy on 7% of the area. Witnout an effective form of slash dispersal, natural regeneration growth may be retarded on the area under these dense piles of slash.

Regeneration potential was estimated to be not limited on 55%, moderately limited on 23% and severely limited on 22% of the plots when using either soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors.

Erosion potential was found to be low on 100% of the unbulldozed area indicating that erosion and siltation would not be expected to be a serious problem on this block.

A considerable amount of advance regeneration was destroyed during harvest and only 59% of the original softwood seedlings remained in an undamaged or slightly damaged condition after harvest. There was a reduction from 81% of the plots with softwood regeneration prior to harvest to 70% following the harvesting operation.

There is a conflict between attempting to reduce soil disturbance and erosion by more uniformly distributing wheel tracks, and reducing advance regeneration damage by reducing the area occupied by wheel tracks. On areas where natural regeneration will be relied on for reforestation an optimum approach could be, to reduce the area occupied by wheel tracks on areas of low erosion potential; and on areas of high erosion potential, to operate the short-wood forwarders such that wheel tracks are more uniformly distributed. On areas where natural regeneration will not be relied on for reforestation the short-wood forwarders should be operated such that wheel tracks are uniformly distributed throughout the block. In a manual/short-wood harvesting system the percentage of the area occupied by wheel tracks depended on the layout of the cut strips. The uniform distribution of these trails will result in a certain amount of advance regeneration damage. It would be difficult to reduce this area with this harvesting system.

Merchantable waste volume totalled 127 m^3 (3.1 m^3/ha) on the block and slightly exceeded the 3.0 m^3/ha coverage allowed by regulation. The greater portion of this waste was in long butting by the fellers at the stump. Proper block layout and harvesting to those boundaries could have produced an additional 1 670 m^3 of merchantable wood.

With proper supervision the manual/short-wood system could be used to harvest riparian strips within acceptable environmental and economic constraints.

APPENDIX II

MCCORMICK LAKE STUDY AREA

An Evaluation of the Manual/Short-wood
Harvesting System

McCORMICK LAKE STUDY AREA

Description of Study Area

The McCormick Lake study area was located northwest of Newcastle in the Restigouche-Bras d'or Ecoregion (Loucks, O.L. 1961). The proposed harvest block was to encompass a large area of budworm damaged wood. Two portions of that block were chosen for the study; a 40 ha area southwest of McCormick Lake and an 89 ha area directly east of the lake. The pre-harvest and post-harvest survey and results were kept separate for each area.

Area Southwest of McCormick Lake

Balsam fir was the predominant tree species on this portion of the study area with 836 merchantable stems per hectare and was intermixed with 140 merchantable stems per hectare of spruce. There were approximately 1 060 unmerchantable stems per hectare of cull softwood trees on the area. There were 104.1 m^3/ha of softwood and 2.3 m^3/ha of hardwood on the block. Branchiness was generally light with less than 30% of the merchantable height containing live branches. Slope on the area was predominantly adverse with 66% of the area in the 0-5% range, 17% in the 6-10% range, 10% in the 11-15% range and 7% in the 16-20% range. The ground roughness of the area was Class I and the entire site had good ground bearing capacity. The soils in this ecoregion are generally stony, sandy loams (Loucks, O.L. 1961). Regeneration was dense in this study area with an average of 15 500 softwood seedlings and 12 600 hardwood seedlings per hectare. Of the regeneration plots assessed; 21% had neither softwood or hardwood regeneration, 69% had softwood seedlings and 55% had hardwood seedlings. Most seedlings were less than 20 cm in height.

Area East of McCormick Lake

Balsam fir and spruce were the predominant tree species on this portion of the study area with 667 merchantable stems per hectare and was intermixed with 87 merchantable stems per hectare of red maple and white birch. There were approximately 660 unmerchantable stems per hectare of small diameter trees and larger cull trees. There were 113.4 m^3/ha of softwood and 8.6 m^3/ha of hardwood on the block. Branchiness was generally light with 31-50% of the merchantable height containing live branches. Slope on the block was predominantly adverse with 68% of the area in the 0-5% range, 16% in the 6-10% range, 13% in the 11-15% range and 3% in the 16-20% range. The ground roughness of the area was Class I and the entire site had good ground bearing capacity. The soils in this ecoregion are generally stony, sandy loams (Loucks, O.L. 1961). Regeneration was dense on the study area with an average of 23 000 softwood seedlings and 20 300 hardwood seedlings per hectare. Of the regeneration plots assessed; 6% had neither softwood nor hardwood regeneration, 88% had softwood seedlings and 84% had hardwood seedlings. Most seedlings were less than 20 cm in height.

Harvest

Both study areas within the block were clearcut of all merchantable species by a manual/short-wood system. Trees were felled and bucked into logs, veneer and pulpwood at the stump then forwarded by short-wood forwarders roadside. Harvesting took place during the summer and fall of 1982 and early summer of 1983 with weather conditions being good both prior to and during the harvesting phase.

Results

Roads and Landings

Roads and bulldozed landings occupied 3.2% of the 40 ha block (study area southwest of McCormick Lake) and 3.2% of the 89 ha block (study area east of McCormick Lake). There was approximately 1.4 km of road constructed on the 40 ha block and the bulldozed width of road plus bulldozed landings averaged 12.1 m in width. There was approximately 2.0 km of road constructed on the 88 ha block and the bulldozed width of road plus bulldozed landings averaged 16.4 m in width.

Ground Disturbance on the Unbulldozed Cutover

Area Southwest of McCormick Lake

The percentage of unbulldozed cutover area occupied by machine tracks and the percentages of area with organic and mineral layer disturbance are shown by slope class in Table 2. The percentage of area occupied by machine travel averaged 13% and generally increased with increasing slope. Organic layer disturbance occurred on 5% of the area. Although there was no organic layer disturbance on slopes from 6-20% a drastic increase in disturbance occurred on slopes in the 16-20% range. There was no mineral layer disturbance.

Area East of McCormick Lake

The percentage of unbulldozed cutover area occupied by machine tracks and the percentages of area with organic and mineral layer disturbance are shown by slope class in

Table 2. Percentage of area occupied by machine tracks, organic layer disturbance and mineral layer disturbance on the Study Area Southwest of McCormick Lake.

Degree of Disturbance	Slope %					
	0-5	6-10	11-15	16-20	20+	All Slopes
	% of cutover area					
PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS						
- Light	7	1	21	---	---	7
- Moderate	---	---	---	50	---	4
- Heavy	4	---	---	---	---	2
Total	11	1	21	50	---	13
PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE						
- Light	4	---	---	38	---	5
- Moderate	---	---	---	---	---	---
- Heavy	---	---	---	---	---	---
Total	4	---	---	38	---	5
PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE						
- Light	---	---	---	---	---	---
- Moderate	---	---	---	---	---	---
- Heavy	---	---	---	---	---	---
Total	---	---	---	---	---	---

Table 3. The percentage of area occupied by machine travel averaged 12% and remained relatively constant for all slopes encountered on the block. Organic layer disturbance occurred on 10% of the area and increased for slopes up to 15%, however a decrease occurred on slopes in the 16-20% range. The severity of disturbance did not appear to increase with slope. There was minimal mineral layer disturbance with only 1% of the area in the light disturbance category.

Slash Dispersal on the Unbulldozed Cutover

Slash on the unbulldozed cutover Southwest of McCormick Lake was absent on 15%, light on 63%, moderate on 15% and heavy on 7% of the area. Slash on the unbulldozed cutover east of McCormick Lake was absent on 36%, light on 32%,

Table 3. Percentage of area occupied by machine tracks, organic layer disturbance and mineral layer disturbance on the Study Area East of McCormick Lake.

Degree of Disturbance	0-5	6-10	11-15	16-20	20+	All Slopes
	% of cutover area					
PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS						
- Light	5	1	4	8	---	4
- Moderate	8	---	10	4	---	6
- Heavy	---	10	---	---	---	2
Total	13	11	14	12	---	12
PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE						
- Light	8	---	21	3	---	8
- Moderate	1	11	---	---	---	2
- Heavy	---	---	---	---	---	---
Total	9	11	21	3	---	10
PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE						
- Light	1	---	---	---	---	1
- Moderate	---	---	---	---	---	---
- Heavy	---	---	---	---	---	---
Total	1	---	---	---	---	1

moderate on 22% and heavy on 10% of the area. The manual/short-wood system produced rows of slash evenly distributed over the entire block. The heavy accumulation of slash occurred when more than two trees were delimbed and/or topped on the same site. Slash accumulation in this heavy category was often greater than one metre.

Post-Harvest Regeneration on the Unbulldozed Cutover

Area Southwest of McCormick Lake

Following the harvesting operation it was estimated there were 14 600 softwood seedlings and 2 100 hardwood seedlings per hectare in an undamaged or only slightly damaged condition, or 94% of the original softwood seedlings and 17% of the original hardwood seedlings remained in an undamaged or only slightly damaged condition. There were softwood seedlings in 69% and hardwood seedlings in 21% of the sample plots following harvesting.

Area East of McCormick Lake

Following the harvesting operation it was estimated there were 12 000 softwood seedlings and 1 200 hardwood seedlings per hectare in an undamaged or slightly damaged condition, or 52% of the original softwood seedlings and only 6% of the original hardwood seedlings remained in an undamaged or only slightly damaged condition. There were softwood seedlings in 55% and hardwood seedlings in 17% of the sample plots following harvesting.

Regeneration Potential on the Unbulldozed Cutover

Regeneration potential was assessed on a plot-by-plot basis on the unbulldozed cutover. The limiting factors considered were soil disturbance, slash accumulation and the natural condition of the site.

Area Southwest of McCormick Lake

Using only soil disturbance as the limiting factor, regeneration was estimated to be not limited in 100% of the plots. Using only slash accumulation as the limiting factor, regeneration potential was estimated to be not limited in 71%, moderately limited in 22% and severely limited in 7% of the plots. The area in the severely limited regeneration potential classification occurred under deep slash piles due to several trees being delimbed and/or topped on that same location. Using only the natural condition of the site as the limiting factor, regeneration potential was estimated to be not limited in 50%, moderately limited in 33% and severely limited in 17% of the plots. Natural regeneration has been severely limited due to advanced raspberry growth. Using soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors regeneration potential was estimated to be not limited in 55%, moderately limited in 30% and severely limited in 15% of the plots.

Area East of McCormick Lake

Using only soil disturbance as the limiting factor, regeneration potential was estimated to be not limited in 97% and moderately limited in 3% of the plots. Using only slash accumulation as the limiting factor, regeneration potential was estimated to be not limited in 67%, moderately limited in 22% and severely limited in 11% of the plots. As was found on the area southwest of McCormick Lake regeneration potential was severely limited on plots occurring under deep slash piles due to several trees being delimbed and/or topped on that same location. Using only the natural condition of the site as the limiting factor, regeneration potential was estimated to be not limited in 72%, moderately limited in 21% and severely limited in 7.0% of the plots. Dense ground cover of unmerchantable shrubs, grass and advanced raspberry growth were the natural factors limiting the regeneration potential on the site. Using soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factor, regeneration potential was estimated to be not limited in 52%, moderately limited in 35% and severely limited in 13% of the plots.

Erosion Potential on Unbulldozed Cutover

Erosion potential was assessed on a plot basis only for the unbulldozed cutover. On the area southwest of McCormick Lake erosion potential was estimated to be low on 100% of the plots. On the area east of McCormick Lake erosion potential was estimated to be low in 97%, medium in 3% and high in 0% of the plots.

Fibre Utilization

Area Southwest of McCormick Lake

Merchantable waste volume averaged 5.28 m^3/ha on the unbulldozed cutover. Of the area sampled 93% of the plots had some waste and 7% of the plots had no waste. Waste in full-trees either left standing or knocked down accounted for 2.96 m^3/ha of the merchantable volume left on the block. Merchantable tops and bolts accounted for 2.11 m^3/ha and long butting accounted for 0.21 m^3/ha of this waste volume. Total merchantable waste on the sampled area was calculated to be 211 m^3 or approximately 5.0% of 4 256 m^3 harvested on the block.[3]

The average stump height on the block was 13.1 cm and the average stump height diameter was 16.2 cm. The average height to diameter ratio was 0.875.

The average top diameter was 8.2 cm for softwood with a range from 6 to 14 cm and 9.0 cm for hardwood with a range from 6 cm to 10 cm.

Area East of McCormick Lake

Merchantable waste volume averaged 15.83 m^3/ha on the unbulldozed cutover. Of the area sampled 100% of the plots contained waste. Waste in full-trees either left standing, knocked down during harvesting operations or blown down accounted for 13.85 m^3/ha of the merchantable volume left on

---

[3] The 4 256 m^3 was obtained from the pre-harvest cruise data for the specific area that was sampled.

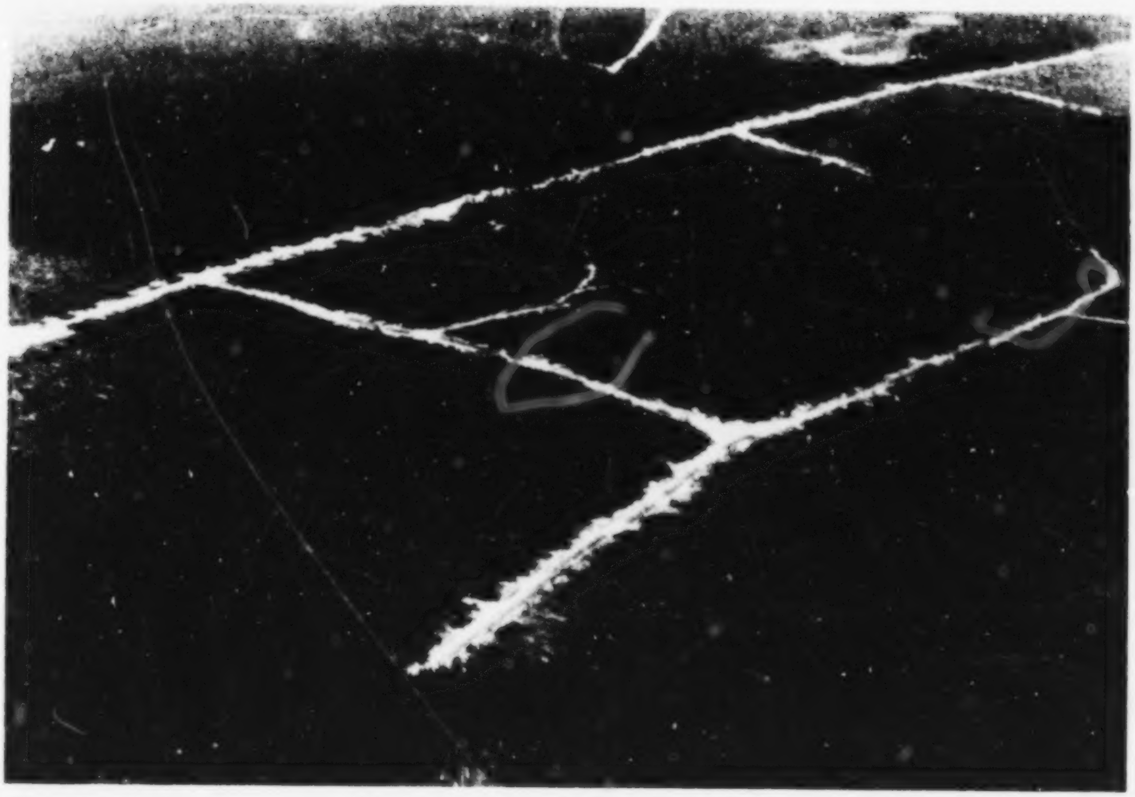


Figure 4.
McCormick Lake Study Area
(Area East of McCormick Lake)

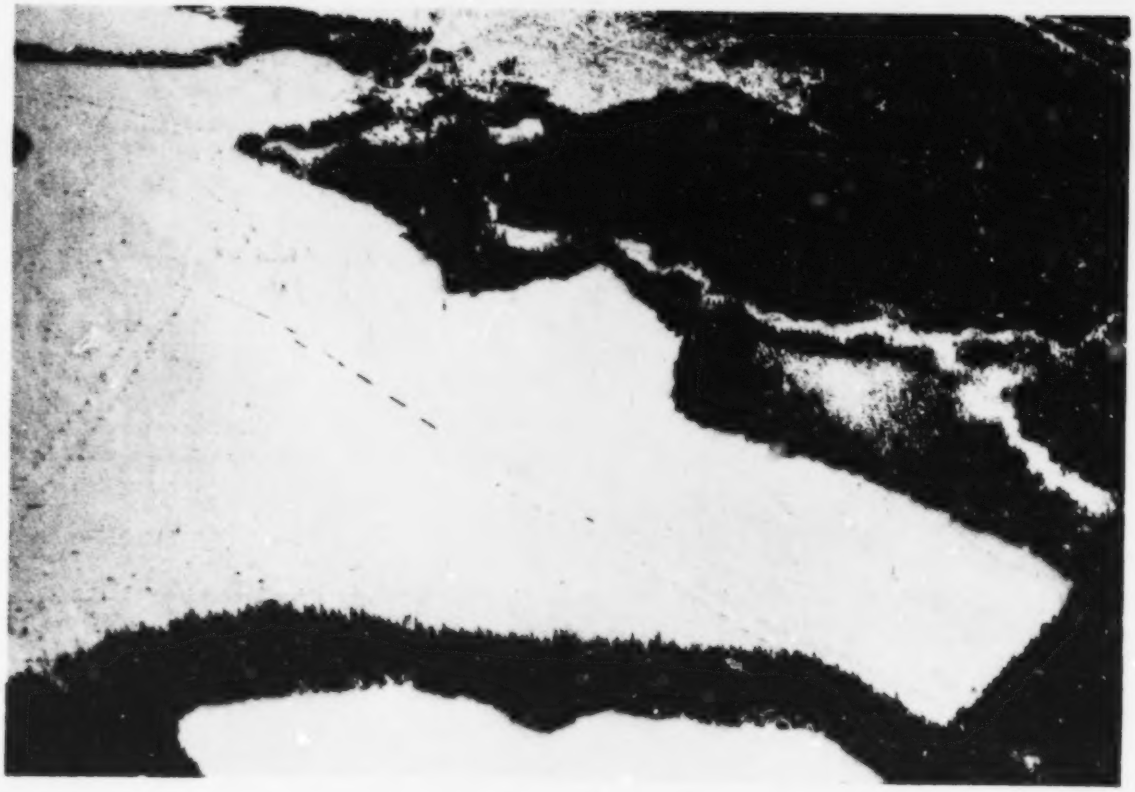


Figure 5.

McCormick Lake Study Area
(Area Southwest of McCormick Lake)

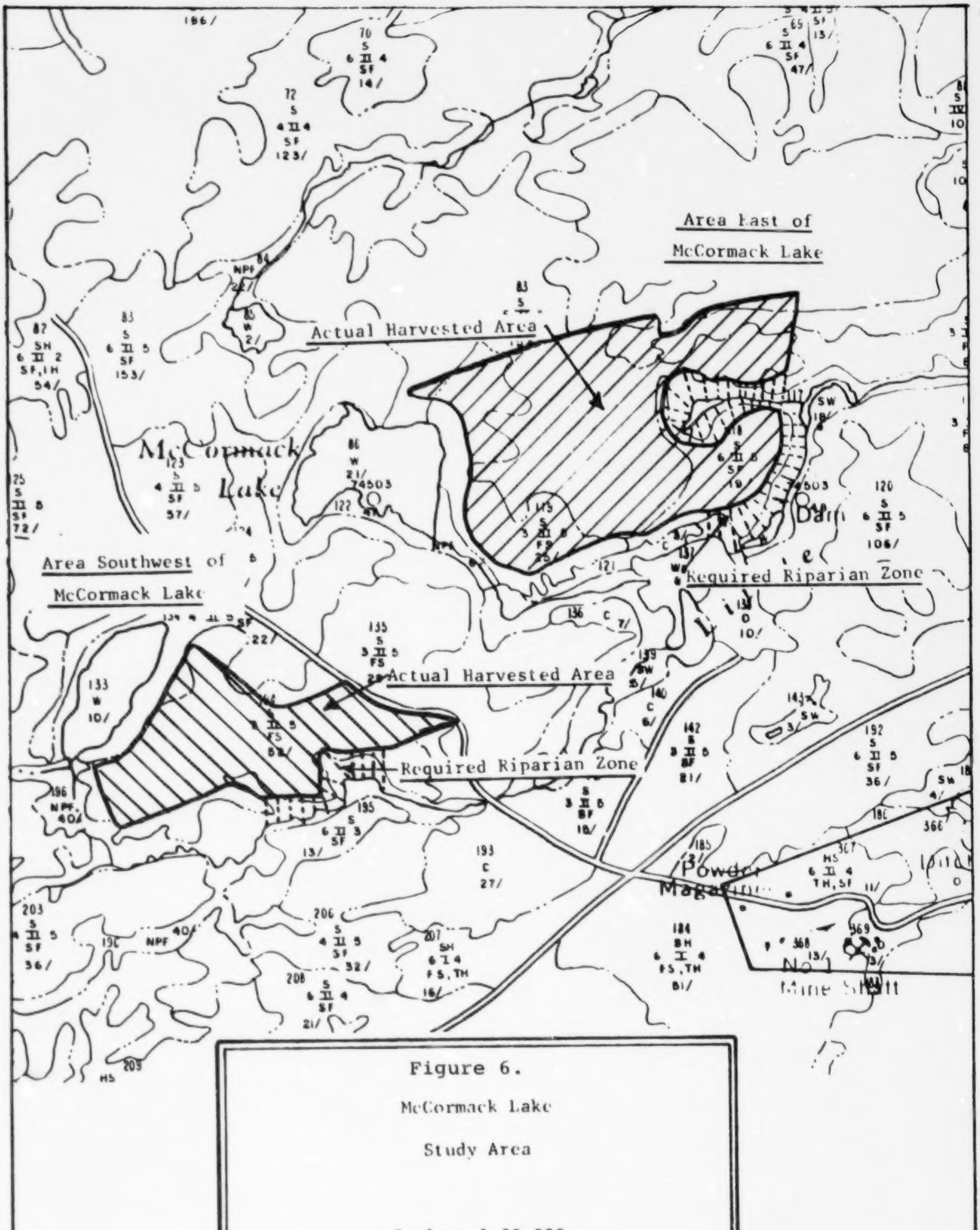


Figure 6.

McCormack Lake

Study Area

Scale - 1:20 000

the block. Merchantable waste in tops and bolts accounted for 1.29 m^3/ha, long-butting accounted for 0.67 m^3/ha while merchantable waste in skids and logs accounted for 0.02 m^3/ha. Total merchantable waste on the sampled area was calculated to be 1 409 m^3 or approximately 13.0% of 10 860 m^3 harvested on the block.[4]

The average stump height on the block was 8.7 cm and the average stump height diameter was 18.2 cm. The average height to diameter ratio was 0.533.

The average top diameter was 8.7 cm for softwood with a range from 6 to 16 cm and 10.5 cm for hardwood with a range from 6 to 24 cm.

Discussion

Roads and Landings

Roads and bulldozed landings occupied 3.2% on each study area which is within the 5% allowable limit as required in the FMM. The average bulldozed width of the logging roads also complies with the requirements and was less than 20 m.

Ground Disturbance on the Unbulldozed Cutover

The proportion of area occupied by machine tracks increased with increasing slope for the area southwest of McCormick Lake but remained relatively constant on the area east of the lake. This would suggest that the short-wood forwarder's manoeuverability was not adversely affected by the gentle slopes (20%) on both areas. The area occupied by machine tracks increased with increasing slope on the area southwest of McCormick Lake. This suggests that the short-wood forwarders did more manoeuvering to negotiate the trails on steeper slopes. Most of the soil damage was caused by wheel tracks with only minimal damage caused by the forwarders knocking over unmerchantable trees. It was often difficult to estimate the area occupied by machine tracks especially on areas where they rode over slash piles.

Machine travel did not necessarily cause damage to the organic layer. Organic layer disturbance occurred on 5% of the area as compared to the 13% of area occupied by wheel tracks on the area southwest of McCormick Lake. The area east of McCormick Lake did show an increase in organic layer disturbance with 10% of the area disturbed compared to the 13% of the area occupied by wheel tracks. Disturbance was generally in the light classification. Medium organic layer disturbance generally occurred on areas where the forwarding machine made more than two passes. Organic layer disturbance did appear to increase with increasing slope, however, the severity of this disturbance did not seem to increase.

---

[4] The 10 860 m^3 was obtained from the pre-harvest cruise data for the specific area that was sampled.

The proportion of area occupied by mineral layer disturbance was minimal with only 1% of the area east of McCormick Lake affected. The disturbance was in the light classification and was generally the result of two or more machine passes. Mineral layer disturbance and the severity of that disturbance did not increase with increasing slope.

The severity of organic and mineral layer disturbance, at least on gentle slopes (20%) appears to be more affected by the number of machine passes rather than slope and for this reason any attempt to reduce the severity of this ground disturbance should be directed at reducing the number of passes the forwarding machines make over the same area.

Slash Dispersal on the Unbulldozed Cutover

The manual/short-wood harvesting system employed on this block produced rows of slash uniformly spaced on trails over the entire area. Heavy slash accumulation occurred when several trees were delimbed and/or topped on the same location resulting in depths greater than one meter. On the area southwest of McCormick Lake heavy slash accumulation occurred on 7% of the unbulldozed area which represented 2.8 ha. On the area east of McCormick Lake heavy slash accumulation occurred on 10% of the unbulldozed area which represented 8.9 ha. In total 11.7 ha could be taken out of production for possibly one or more rotations.

Post-Harvest Regeneration on the Unbulldozed Cutover

There was a considerable reduction in the number of healthy seedlings on both portions of the study area following the harvesting operations, however, substantial numbers still remain. The number of plots with softwood regeneration remained at 69% for the area southwest of McCormick Lake, however dropped from 88% before harvest to 55% after harvest on the area east of McCormick Lake. With the amount of slash present on the block it is unlikely that a 60% stocking level can be achieved by natural regeneration on the portion east of McCormick Lake. Most of the damage to the advanced regeneration on the block was caused by the forwarding machines' wheels. The uniform distribution of the forwarding machines' tracks over both portions of the study area is a characteristic of a manual/short-wood harvesting operation and it is highly unlikely that an effective reduction in the area occupied by the wheel tracks can be achieved.

Regeneration Potential on the Unbulldozed Cutover

Soil disturbance appeared to have little detrimental affect on the ability of both study areas to be regenerated naturally. Slash accumulation and the natural condition of the site following harvesting had the most detrimental effect on the capability of the study area to regenerate naturally. The concentration of heavy slash especially where several trees were delimbed and/or topped on the same site severely limited that area to produce natural regeneration within one or two rotations. The short-term effect of the heavy rows of slash present may be to retard the growth of the tolerant softwood regeneration present under the slash. However, in the long-term this slash may provide an effective filter layer so that the tolerant softwood seedlings do not become scorched by the direct exposure to the sunlight. Softwood tops contained in these slash piles may also provide an immediate seed source. The advanced raspberry growth present after harvesting also severely limits a portion of the study area to produce natural regeneration. Using soil disturbance, slash accumulation and/or the natural condition of the site as limiting factors regeneration potential was estimated to be severely limited on 15% of the area southwest of McCormick Lake and 13% of the area east of McCormick Lake.

Erosion Potential on the Unbulldozed Cutover

With this particular combination of machinery and site, erosion and siltation would not be expected to be a problem, as 100% of the area southwest of McCormick Lake and 97% of the area east of McCormick Lake were classified as having low erosion potential. The site was well-drained, had good ground bearing capacity and slopes did not exceed 20%. On a poorer site with a bearing capacity not capable of supporting more than two passes of the forwarding machine, the ground disturbance could probably create a high degree of erosion and siltation potential. Erosion potential could also increase on areas with slopes greater than 20% especially when the forwarders make several passes over the same area.

Fibre Utilization

Merchantable waste volume averaged 5.28 m^3/ha on the area southwest of McCormick Lake and 15.83 m^3/ha on the area east of McCormick Lake. Both areas exceeded the 3.0 m^3/ha allowable merchantable waste requirement outlined in the FMM. Waste in full-trees either left standing, knocked down during the harvesting operation or blown down, accounted for much of this merchantable waste volume. The average diameter of these merchantable full-trees left was 15.4 cm on the area southwest of McCormick Lake and 18.1 cm on the area east of McCormick Lake. Waste in tops and bolts and in long butts also contributed to this volume. The wasteful cutting practices on this type of harvesting operation originate at the stump and are dependent on the decisions each chainsaw operator makes. These are subjective judgements and individual fellers will differ in their decisions; however, with proper direction and supervision much of this waste could be eliminated.

Stumps were generally cut low resulting in little or no waste. The higher stumps generally occurred in the smaller diameter classes but in most cases these stump heights were less than the 30 cm requirement as outlined in the FMM.

There is no actual topping diameter specified by regulation in New Brunswick, however waste remaining in oversized tops is accounted for within the Merchantable Waste Volume Determination procedures in the FMM. The average top diameter for softwood was 8.2 cm on the area southwest of McCormick Lake and 8.7 cm on the area east of McCormick Lake with a top diameter limit of 14 cm and 16 cm respectively. The average top diameter for hardwood was 9.0 cm and 10.5 cm for the two areas with a top diameter limit of 10 cm and 24 cm respectively. Although this may indicate that some waste is occurring from premature topping, other factors such as tree form and branch characteristics have to be taken into consideration.

Suitability to Existing Forest Conditions

The manual/short-wood harvesting system appeared to be well-suited to this particular area. The block was on a well-drained upland site with very few springs and good ground bearing capacity. Mineral layer disturbance was minimal and the forwarding machines were capable of operating on slopes up to 20% with little if any increase in soil disturbance. Although there were considerably fewer seedlings present following the harvesting operation the number of healthy seedlings remained in large numbers. The area east of McCormick Lake is unlikely to meet acceptable stocking requirements as indicated by the reduction in the number of plots with softwood regeneration present. The heavy rows of slash accumulated on the site, and the presence of advanced raspberry growth after harvesting severely limit the potential of the site to product natural seedlings and also inhibit reforestation efforts.

Suitability for Harvesting Environmentally Sensitive Areas

Based on field observations and the results of the assessments made on this particular harvest block it is the author's opinion that the manual/short-wood system could be used to harvest, within acceptable environmental limitations, wood in riparian strips and deer yards.

The manual/short-wood system is suited for harvesting in strips, patches or larger clearcuts. Selective cutting in riparian zones would be extremely limited with this type of harvesting system. It is conceivable however that selective cutting could take place in riparian zones having a high percentage of sawlog material and few stems per hectare of small diameter trees. The orientation of the cut strips using this harvesting system would normally be at right angles to the watercourse regardless of the width of the riparian zones. Each trail cutter would normally work in strips ranging from 20 m to 30 m in width. However, narrower strips could be cut as long as the width is sufficient to permit the porters to manoeuver within these strips. The length of the trail into the riparian zones will depend on the condition of the site. Slope, ground roughness and ground bearing capacity will directly influence the ability of the porters to penetrate into the riparian zone.

The forwarders appeared to have little difficulty in negotiating slopes up to 20% provided that the ground roughness and bearing strength of the soil were such that few obstacles impeded the machines manoeuverabilty. Short-wood forwarders would be severely limited on slopes greater than 20% and on sites with a high degree of ground roughness. Areas of poor ground strength should also be avoided because severe ground disturbance will occur.

Conclusions

The manual/short-wood system did not appear to cause any major problems on either portion of this particular study area.

The area occupied by roads and landings was 3.2% for both sites which is within the requirements outlined in the FMM.

Machine tracks occupied 13% of the area southwest of McCormick Lake and organic layer disturbance occupied 5% of the unbulldozed portion of the clearcut. On the area east of McCormick Lake, machine tracks occupied 12% of the area and organic and mineral layer disturbance occupied 10% and 1% respectively. The amount of soil disturbance appeared to increase with increasing slope on both areas however the severity of this disturbance did not.

Slash was absent on 15%, light on 63%, moderate on 15% and heavy on 7% of the unbulldozed area southwest of McCormick Lake. On the area east of McCormick Lake slash accumulation was estimated to be absent on 36%, light on 32%, moderate on 22% and heavy on 10% of the unbulldozed area. Without an effective form of slash dispersal, natural regeneration growth may be retarded on the area with these dense piles of slash.

Regeneration potential, on the area southwest of McCormick Lake, was estimated to be not limited in 55%, moderately limited in 30% and severely limited in 15% of the plots. Regeneration potential, in the area east of McCormick Lake, was estimated to be not limited in 52%, moderately limited in 35% and severely limited in 13% of the plots. Regeneration potential was based on using either soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors.

Erosion potential was estimated to be low on 100% of the area southwest of McCormick Lake and 97% of the area east of the lake. This indicates that erosion and siltation would not be expected to be a serious problem on either portions of the study area.

Softwood regeneration damage was minimal on the area southwest of McCormick Lake and the number of plots containing healthy softwood seedlings remained at 69% following the harvesting operation. However a considerable amount of advanced softwood regeneration was destroyed on the area east of McCormick Lake. Only 52% of the original softwood seedlings remained in an undamaged or slightly damaged condition following harvesting. There was a reduction from 88% of the plots with softwood regeneration prior to harvest to 55% following harvesting. Even though large numbers of softwood seedlings remain on both areas, it is unlikely that the 60% stocking standard can be attained on the area east of McCormick Lake.

There is a conflict between trying to reduce soil disturbance and erosion by more uniformly distributing wheel tracks, and reducing advance regeneration damage by reducing the area occupied by wheel tracks. On areas where natural regeneration will be relied on to reforest the area an optimum approach could be, to reduce the area occupied by wheel tracks on areas of low erosion potential thus reducing the amount of damage to advance regeneration, and on areas of high erosion potential to operate the short-wood forwarder such that wheel tracks are more uniformly distributed, thus reducing the possibility of soil disturbance and erosion. On areas where natural regeneration will not be relied on to reforest the area the forwarder should be operated such that wheel tracks are uniformly distributed throughout the block. In a manual/short-wood system the distribution of the area occupied by wheel tracks depends on the layout of the cut strips. The uniform distribution of these trails will result in a certain amount of advance regeneration damage. It would be difficult to reduce this area with this harvesting system.

Merchantable waste volume totalled 211 m^3 on the area southwest of McCormick Lake and 1 409 m^3 on the area east of the lake. Both areas exceeded the 3.0 m^3/ha requirement outlined in the FMM under Merchantable Waste Volume Determination. Most of this waste was in full-trees either on the ground or left standing and was primarily the result of poor supervision.

With proper supervision and choice of site the trail-cut/porter system could be used to harvest riparian strips within acceptable environmental and economic constraints.

APPENDIX III

ROCKY LAKE STUDY AREA

An Evaluation of the Mechanical/Full-tree/ Short-wood Harvesting System

ROCKY LAKE STUDY AREA

Description of Study Area

The Rocky Lake study area was located northwest of Saint John in the Magaguadavic-Hillsborough ecoregion (Loucks, O.L. 1961). Spruce was the predominant tree species on the study area with 1 005 merchantable stems per hectare and was intermixed with 125 merchantable stems per hectare of a variety of species; the major of which were red maple, white birch and eastern white cedar (*Thuja occidentalis* L.). There were approximately 494 unmerchantable stems per hectare of small diameter trees (less than 10 cm dbh) and larger cull trees. There were 116.6 m^3/ha of merchantable softwood and 12.7 m^3/ha of merchantable hardwood on the block. Branchiness was generally light with 31 - 50% of the merchantable height containing live branches. Slope on the block was predominantly favorable with 40% of the area in the 0 - 5% range, 30% in the 6 - 10% range, 13% in the 11 - 15% range, 2% in the 16 - 20% range, 7% in the 21 - 25% range and 8% in the 26+% range. Ground roughness varied throughout the block with 40% of the area of Class 1 roughness, 45% of the area of Class 2 roughness and 15% of the area of Class 3 roughness. The bearing capacity or ground strength was predominately good with 68% of the area in this classification, 22% was of moderate strength while 10% of the harvested area had poor ground bearing capacity.

The soil consisted of rock and boulders covered by a thin layer of organic material and sandy loam. Though most of the site was dry and well-drained, low portions bound by these rock outcrops were poorly drained with a thick organic layer and wet soils. The average depth of organic layer was 15 cm.

Regeneration was dense on the study area with an average of 86 200 softwood and 14 900 hardwood seedlings per hectare. Of the regeneration plots assessed 5% had neither softwood nor hardwood regeneration; 83% had softwood seedlings and 53% had hardwood seedlings. Most seedlings were less than 20 cm in height.

Harvest

The block was clearcut of all merchantable species by a combination of harvesting systems. Most of the block was harvested by a mechanical full-tree/short-wood system. Trees were felled and bunched by a Kockums 880 Tree King, full-trees were skidded either to designated areas within the block or to roadside by a grapple skidder. Wood processed on the block was forwarded to roadside in short-wood form by a Kockums short-wood forwarder.

A small portion of the block, where rock outcrops and large boulders made it exceedingly difficult for mechanical harvesting, was harvested by a manual/short-wood system. Trees were normally felled and bucked to length then forwarded to roadside by a short-wood forwarder.

Harvesting took place in the summer and fall of 1982 with weather conditions being good both prior to and during the harvesting phase.

Results

Roads and Landings

Roads and unbulldozed landings occupied 17.1% of the 91 ha block; 1.9% (1.8 ha) was bulldozed and 15.2% (13.8 ha) was occupied by piled wood or slash. The area occupied by most of the slash was on the block and not at roadside. Roadside slash occupied only 1.9% of the area while slash piles concentrated throughout the block by the off-road processing machinery accounted for 13.3% of the area. There was approximately 1.24 km of road on the block with the average width of bulldozed area being 13.5 m.

Ground Disturbance on the Unbulldozed Cutover

The percentage of the unbulldozed cutover area occupied by machine tracks and the percentage of area with organic and mineral layer disturbance are shown by slope class in Table 4. Landings were excluded from the estimates because they could not be properly sampled due to the heavy accumulation of slash. The percentage of area occupied by machine travel averaged 38%, though this remained relatively constant for most slopes a slight decrease was observed for the 11 - 15% range while an increase in area occurred in the 16 - 25% slope range. The percentage of area with organic layer disturbance followed the same trend with the average on all slopes being 32%. The percentage of area occupied by mineral layer disturbance averaged 13% with slight increases in the 6 - 10% and 21 - 25% ranges. The severity of disturbance and area occupied by machine travel did not appear to increase on extreme slopes (26+%).

Slash Dispersal on the Unbulldozed Cutover

Slash on the unbulldozed cutover was estimated to be absent on 49%, light on 31%, moderate on 4% and heavy on 16% of the area. The heaviest accumulation of slash was not concentrated at roadside but was scattered in numerous piles throughout the block. These slash piles varied in size and depth and were related to the volume of wood which was brought to a particular landing.

Table 4. Percentage of area occupied by machine tracks, organic layer disturbance and mineral layer disturbance on the Rocky Lake Study Area.

Degree of Disturbance	0-5	6-10	11-15	16-20	21-25	26+	All Slopes
	Slope %						
	% of cutover area						
PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
- Light	19	14	25	---	---	4	15
- Moderate	8	3	---	---	25	25	10
- Heavy	9	23	---	100	25	8	13
Total	36	40	25	100	50	37	38
PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
- Light	15	9	9	---	23	12	14
- Moderate	2	4	9	95	1	3	5
- Heavy	11	19	10	5	27	14	13
Total	28	32	28	100	51	29	32
PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
- Light	4	2	---	5	4	8	3
- Moderate	---	2	7	---	---	3	2
- Heavy	5	16	3	---	25	---	8
Total	9	20	10	5	29	11	13

Post-Harvest Regeneration on the Unbulldozed Cutover

Following the harvesting operation it was estimated there were 15 500 softwood and 220 hardwood seedlings per hectare in an undamaged or only slightly damaged condition or 18% of the original softwood seedlings and 1.5% of the original hardwood seedlings remained in an undamaged or only slightly damaged condition after harvest. There were softwood seedlings in 43% and hardwood seedlings in 3% of the sample plots following the harvest. There was no softwood or hardwood regeneration in 57% of the plots.

Regeneration Potential on the Unbulldozed Cutover

Regeneration potential was assessed on a plot basis on the unbulldozed cutover including unbulldozed landings and was assessed based on soil disturbance, slash accumulation and the natural condition of the site as the limiting factors. Using only soil disturbance as the limiting factor, regeneration potential was estimated to be not limited in 58%, moderately limited in 27% and severely limited in 15% of the plots. Using only slash accumulation as the limiting factor, regeneration potential was estimated to be not limited in 59%, moderately limited in 19% and severely limited in 22% of the plots. Using only the natural conditions of the site as the limiting factor, regeneration potential was estimated to be not limited in 23%, moderately limited in 42% and severely limited in 35% of the plots. Using soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors, regeneration potential was estimated to be not limited in 25%, moderately limited in 31% and severely limited in 44% of the plots.

Erosion Potential on the Unbulldozed Cutover

Erosion potential was assessed on a plot basis for the unbulldozed portion of the cutover. Erosion potential was estimated to be low on 66%, Medium on 22% and High on 12% of the area. The erosion potential was high over areas where the forwarding machines made several passes to and from the landings.

Fibre Utilization

Merchantable waste volume averaged 4.39 m^3/ha on the entire block and 4.31 m^3/ha on the cutover area excluding slash piles. Slash piles were not sampled separately but the samples that fell entirely within these slash piles indicate there was approximately 7.42 m^3/ha of merchantable waste on these areas. Of the area sampled 92.5% of the plots had some waste and only 7.5% of the plots had no waste. Waste in merchantable trees accounted for 66% while bolts and tops accounted for 27% of the total merchantable waste volume on the block. Total merchantable waste on the block was calculated to be 400 m^3 or approximately 3.4% of the 11 766 m^3 harvested.[5]

The average stump height on the block was 16.2 cm and the average stump height diameter was 18.7 cm. The average height to diameter ratio was 0.984.

The average top diameter was 7.7 cm for softwood with a range from 4 to 14 cm and 9.7 cm for hardwood with a range from 6 to 14 cm.

---

[5] Scale sheets for blocks 461382 and 463182 were mistakenly combined, therefore the volume of primary forest products produced on the block can only be calculated from cruise data obtained before harvest. The cruise indicated an average volume of 129.3 m^3/ha of merchantable wood or 11 766 m^3 for the block.

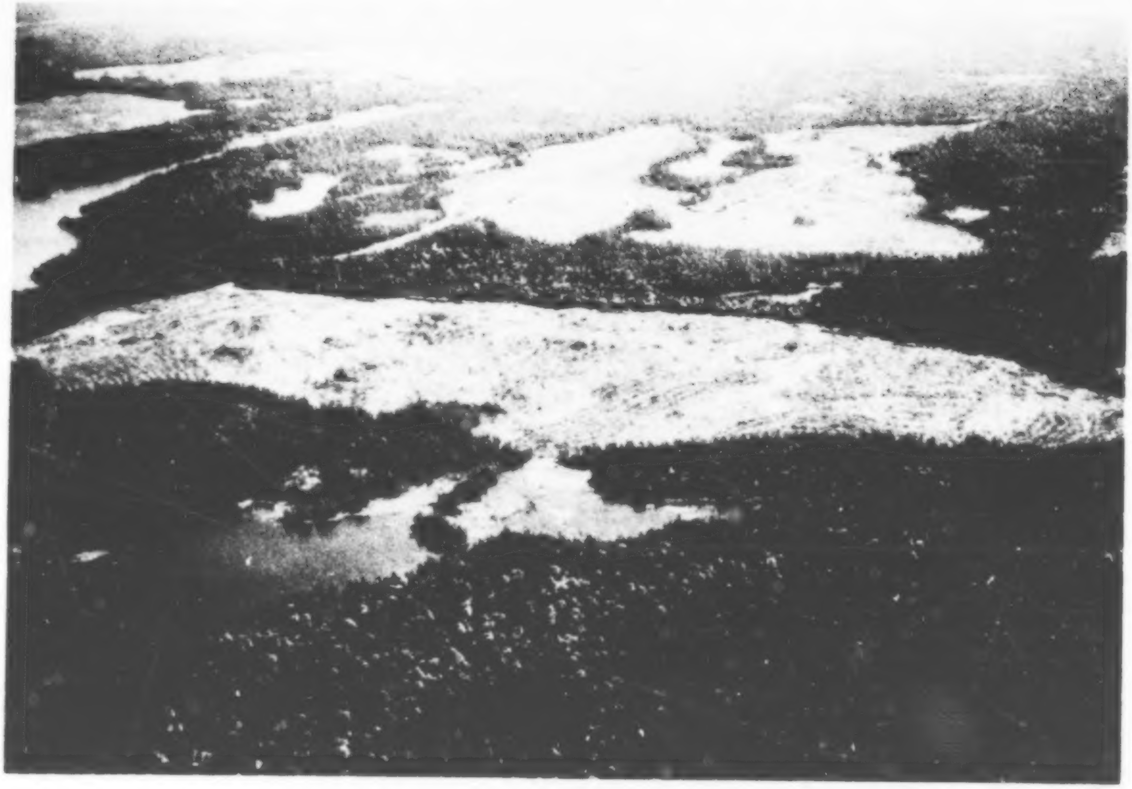


Figure 7.
Rocky Lake Study Area

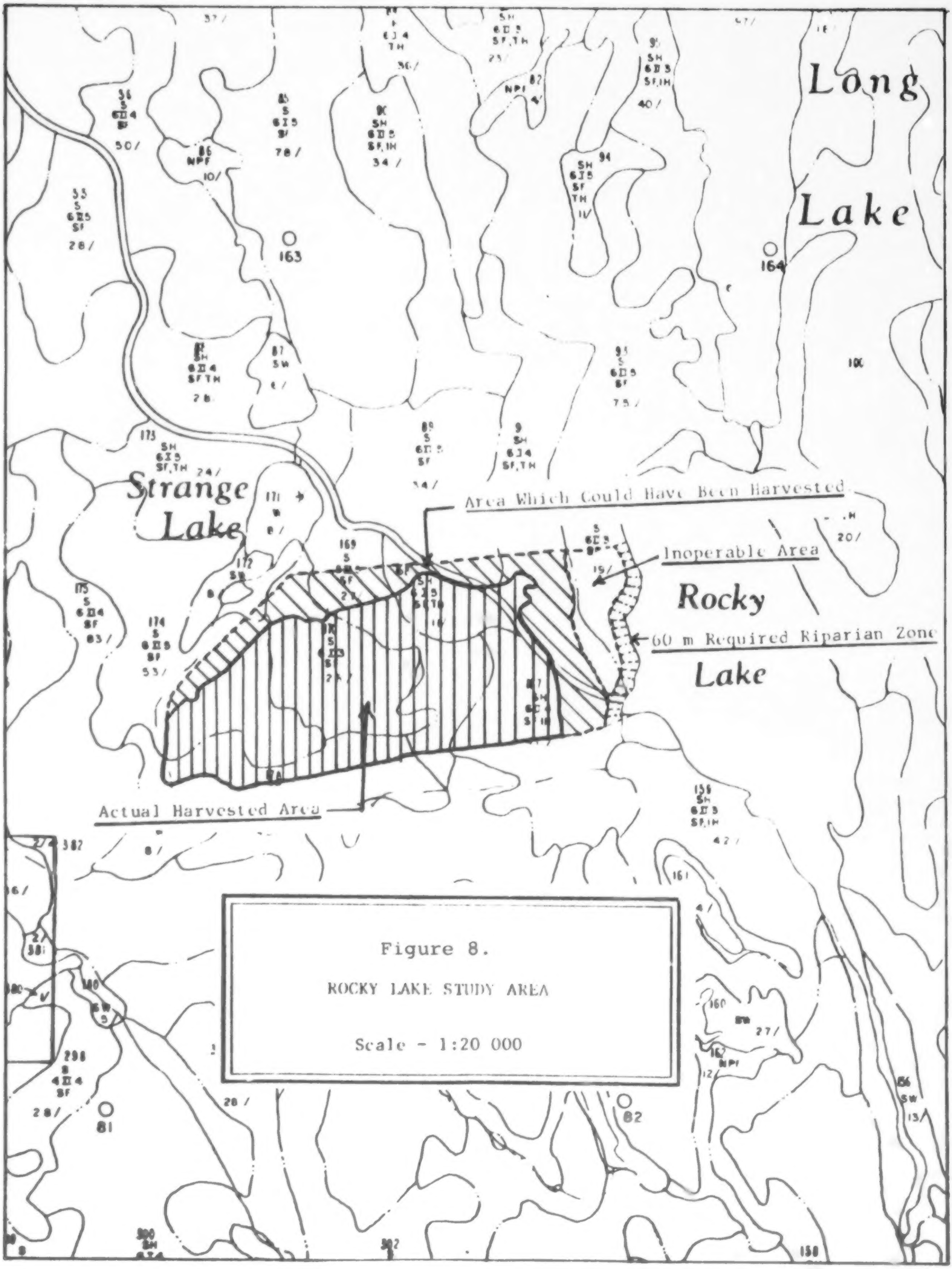


Figure 8.

ROCKY LAKE STUDY AREA

Scale - 1:20 000

The proposed harvest block was to encompass approximately 144 ha, the actual harvested area however was 91 ha. Approximately 24 ha along the proposed south side of the block was not cut to provide the required 500 m leave strip between adjacent cuts. The actual cut could have been extended to include an additional area of 29 ha which would have produced an additional 3750 m^3 merchantable wood.

In total the block could have yielded an additional 4 150 m^3 of wood by eliminating merchantable waste and extending the actual cut to include those areas that were operable with this type of harvesting system.

Discussion

Roads and Landings

Roads and landings occupied 17.1% of the 91 ha block which is more than 3 times the 5% of area allowable under the harvesting rules as described in the FMM. Without any form of slash dispersal this area will be taken out of production for one or more rotations. As bulldozed areas only occupy 1.9% of the area the harvesting requirements under the FMM could be met by proper slash dispersal. Because the slash is spread out more on the cut than concentrated at roadside an effective method of slash dispersal may be in scattering the piles and spreading it over a larger area by mechanical means. There is inherent danger in burning this slash because the fire may be intense enough to burn off the organic layer (average depth 15 cm) exposing the layer of rock and boulders underneath.

Ground Disturbance on the Unbulldozed Cutover

The area occupied by wheel tracks on the unbulldozed cutover accounted for 38% of the harvested area, though this remained constant for most slopes there was an increase in area occupied by machine passes in the 16 - 25% range. The area occupied by machine passes in the 26+% range was slightly less than the average for the block suggesting that the limiting factor for machine manoeuverability was not slope but rather ground roughness. Machine travel did cause damage to the organic layer in that 32% of the area was disturbed. Though machine tracks did account for some of the more severe disturbance a substantial area was damaged by the full-trees being dragged over the thin organic layer by the grapple skidders. The shallow rooted organic layer easily pulled away from the underlying rock and boulders. The area occupied by mineral layer disturbance was 12% with a substantial portion of this (8%) in the heavy disturbance classification. The severity of this disturbance did not appear to increase with slope and could indicate that the degree of disturbance is more closely related to the amount of machine travel than it is to the slope. The ground roughness dictated that on a large area of the block the same route was used by the grapple skidder travelling to the landings where on another block with fewer obstructions the operator might have been able to reduce the number of passes over the same area.

Slash Dispersal on Unbulldozed Cutover

The heaviest accumulation of slash was concentrated in numerous piles scattered throughout the block, caused by the off-road delimbing and topping by the Kockums processor. These piles occupied an area of approximately 13.3% of the total area harvested. This means that without some form of effective slash disposal 12.2 ha may be taken out of production for possibly one or more rotations. Slash was, however, estimated to be absent or light on 80% of the total harvested area posing no barrier to advanced regeneration or reforestation efforts.

Post-Harvest Regeneration on Unbulldozed Cutover

There was a considerable reduction in the number of healthy seedlings on the block following the harvesting operation, however substantial numbers still remain. The number of plots with softwood regeneration dropped from 83% before harvest to 43% after harvest which indicates that a 60% stocking level by natural regeneration is unlikely to occur. The action of the tops being dragged over much of the area caused most of the damage to the advanced regeneration by uprooting the thin organic and mineral layer which loosely clung to the underlying layer of rock and boulders. Harvesting the block in the winter when there is a sufficient cushion of snow would probably reduce this damage. Less damage to the advanced regeneration could also be accomplished by changing the type of harvesting system. A manual/short-wood operation or a feller forwarder would reduce the damage to the advance regeneration by forwarding the trees off the site rather than skidding the full-trees over the cutover area.

Regeneration Potential on Unbulldozed Cutover

Using soil disturbance, slash accumulation and/or the natural condition of the site, regeneration potential was estimated to be severely limited on 44% of the area following harvest. The excessive disturbance to the organic and mineral layer exposing boulders and ledge and the heavy accumulation of slash should have a detrimental effect on the capability of the area to regenerate naturally. An effective form of slash dispersal and artificial reforestation would probably be the required remedies. Reducing the severity of disturbance by forwarding the full-trees to roadside or by harvesting the block during winter months would have increased the potential of the site to regenerate naturally.

Erosion Potential on the Unbulldozed Cutover

Erosion potential was estimated to be high on 12% of the harvested area which is a significant area to be stripped of its mineral soil. The high degree of erosion potential occurred near skidways or landings where the grapple skidders made several passes over the same area. The action of the wheeled tracks and the dragging of the full-trees created rutting and severe scraping and gouging of the mineral soil leaving the area quite susceptible to erosion. Ground disturbance increased with the number of machine passes, therefore to reduce the disturbance resulting in less erosion potential, machine passes over those certain areas must be kept to a minimum.

Fibre Utilization

The average merchantable waste volume for the entire block was 4.39 m^3/ha which exceeds the 3.0 m^3/ha allowable in the FMM. Most of the merchantable waste (66%) was in the form of small diameter trees with an average breast height diameter of 12 cm. Each phase of the mechanical operation could have attributed to full trees being left on the block. The feller-buncher operator may have intentionally knocked down these small diameter trees thinking they did not meet merchantable size or unintentionally knocked them to the ground while manoeuvering the machine. The grapple skidder operator, while grappling a bunch of trees, may fail to secure a small diameter tree or lose one from the grapple while skidding to the landings. Small diameter trees were also buried in the piles at the landings and probably were undetectable by the delimber/slasher operator while delimbing.

Tops and bolts accounted for 27% of the total merchantable waste volume on the block. Breakage either in the felling, skidding or processing phase accounted for most of this waste.

Stumps were generally cut low, with the larger diameter trees often being cut flush with the ground by the shear. Many of the higher stumps occurred in the smaller diameter classes where operators did not take time to position the shear for proper felling. The positioning of the felling head on the tree while manoeuvering around rock and boulders could also have produced slightly higher stumps.

There is no actual topping diameter specified by regulation in New Brunswick, however, waste remaining in oversized tops is accounted for within the Merchantable Waste

Volume Determination Procedures of the FMM. The average top diameter of 7.7 cm for softwood and 9.7 cm for hardwood indicate that little waste resulted from premature topping; with the softwoods being slightly better utilized than the hardwoods. However, the ranges of top diameters of up to 14 cm in softwood and 14 cm in hardwood indicate that some waste occurred from oversized tops. Some difficulty was encountered when delimbing hardwoods and trees were generally topped when the first whorl of large branches was encountered.

An additional 3 750 m^3 of fibre could have been harvested if the actual cut was extended to the original proposed boundary especially toward Rocky and Strange Lakes. This area appeared to be very similar to the harvested site with the maximum slope not being any greater than the maximum slope found on the actual cut, without the construction of additional extraction roads, these isolated areas of standing timber will in all likelihood never be cut. Proper block layout is essential so that all merchantable timber accessible at the time of harvest within a particular area is removed.

Suitability to Existing Forest Conditions

The mechanical/full-tree/short-wood harvesting system employed on this site caused some damage to the capacity of this area to produce a future vigorous stand of timber. However, the resulting damage was probably more dependent on the poor quality of the site rather than the type of harvesting equipment used. The ground bearing capacity of the site suited the heavy equipment however the skidding of full trees over the thin organic and mineral soil layer exposed the underlying layer of boulders and ledge. This type of disturbance contributed to most of the irreparable damage to the site. In the poorly drained areas of the block, characterized by a thick organic layer and wet soils, the machines created deep ruts and mucking of the mineral and organic layers. The off-road processing of the full-trees resulted in an unacceptable area of the block being taken up by slash piles, these areas can be returned to tree producing capabilities by an effective form of slash dispersal.

Although there were considerably fewer seedlings present following the harvesting operation, large numbers of undamaged softwood seedlings still remained, however the 60% stocking level may not be possible as indicated by the reduction in the number of plots with regeneration present.

Suitability for Harvesting Environmentally Sensitive Areas

It is difficult to judge whether or not the mechanical system used on this particular area would be suited for harvesting wood in riparian strips and deer yards. Certainly this system works best when large areas can be cleared with room for manoeuvering both the feller buncher and grapple skidder. Selective cutting in riparian zones would not be practicable with this type of system. Wide strip cuts, patch cuts or clearcuts within riparian zones would be the types of harvesting methods suitable with this particular system. The site should be of good ground bearing capacity with few springs; where the ground strength will not support the machines, severe ground disturbance will result. The Tree King and grapple skidder had little difficulty working on moderate slopes ranging from 20 - 30%, they may be severely limited on slopes greater than these.

The width and slope of the riparian zone would determine the orientation of the cut strips; wide riparian zones which would normally be associated with steeper slopes would probably have cut strips oriented perpendicular to the watercourse while narrow riparian zones which would normally be associated with more gradual slopes would probably have the cut strips oriented parallel to the watercourse.

In most cases the harvesting system would only be used to harvest in riparian strips where they are adjacent to a regular harvest block. The decision of whether to use this system to harvest within the riparian zone should only be made as cutting progresses on the regular block and the effect these machines are having on that particular site can be observed. When damage occurs on the regular block that is unacceptable for harvesting within riparian zones, an alternative harvesting method within the riparian zone will have to be chosen.

Conclusions

The mechanical/full-tree/short-wood harvesting system used on this block did cause some damage to the site. The excessive disturbance to the organic and mineral layer and the heavy accumulation of slash scattered throughout the block would be expected to have a detrimental effect on the capacity of the site to regenerate by natural. Due to the regeneration damage and slash accumulation, it is imperative that the site receive silvicultural treatment to improve the capacity of the area to grow a future vigorous stand of timber. The damage, however, was more dependent on the poor quality of the site rather than the type of harvesting system used. Conventional manual fell and tree-length skidding would have probably caused similar results. A harvesting system employing an off-ground total forwarding of the wood such as a manual/short-wood system would probably have done the least damage.

The area occupied by roads and landings was 17% and is more than 3 times the 5% of area allowable under the harvesting rules as described in the FMM. Without an effective form of slash disposal approximately 15% of the area will be taken out of production for one or more rotations.

The proportion of area occupied by machine travel averaged 38% resulting in organic layer disturbance and mineral layer disturbance to be 32% and 12% respectively for the entire unbulldozed area. The severity of disturbance did not appear to increase with increasing slope but rather was more dependent on ground roughness and bearing capacity. The area occupied by severe gouging or scraping of the mineral soil was 8% for the unbulldozed area.

Slash on the block was estimated to be absent on 49%, light on 30%, moderate on 4% and heavy on 16% of the unbulldozed area. The 16% of area in the heavy slash classification occurred on landings scattered throughout the block.

Regeneration potential was estimated to be not limited in 25%, moderately limited in 31% and severely limited in 44% of the plots when using either soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors.

Erosion potential was estimated to be low on 66%, medium on 22% and high on 12% of the plots. Heavy erosion took place where the machine made several passes causing rutting from the tires and gouging and scraping of the mineral layer by the tops being dragged over the rather thin organic and mineral layer.

A considerable amount of advance regeneration was destroyed during harvest and only 18% of the original softwood seedlings remained in an undamaged or slightly damaged condition after harvest. There was a reduction from 83% of plots with softwood regeneration prior to harvest to 43% following harvest. Even though large numbers of softwood seedlings remain, a 60% stocking level may not be attained and artificial reforestation may be required.

There is a conflict between trying to reduce soil disturbance and erosion by more uniformly distributing machine tracks, and reducing advance regeneration damage by reducing the area occupied by machine travel. In a mechanized operation such as this the distribution of area occupied by both the feller buncher and the grapple skidder was quite uniform. It would be difficult to reduce the amount of advanced regeneration damage on this particular site with this type of harvesting system. The areas with the most severe soil disturbance and erosion potential occurred on or near repeatedly used skid trails.

The uniform distribution of these skid trails would reduce the severity of disturbance, however, restricted by boulders, rock outcrops and areas of poor bearing strength the grapple skidder operator was constrained to use the same trail for numerous passes. On a better quality site with fewer obstacles a uniform distribution of skid trails could be achieved reducing the severity of ground disturbance.

Merchantable waste volume totalled 400 m^3 on the block and exceeded the 3.0 m^3/ha allowed by regulation. The greater portion of the waste (66%) was in the form of small diameter trees left on the ground after harvest. Proper block layout and harvesting to those boundaries could have produced an additional 3 750 m^3 of merchantable wood.

This mechanical/full-tree/short-wood harvesting system would be quite limited in harvesting riparian strips under acceptable environmental and economical constraints. Certainly on choice sites with proper planning and supervision this system could be feasible however, realizing the damage to advance regeneration and the heavy accumulation of slash, some effective form of slash dispersal and artificial reforestation would probably be required following harvesting.

APPENDIX IV

ORMOND LAKE STUDY AREA

An Evaluation of the Manual/Full-tree Harvesting System

ORMOND LAKE STUDY AREA

Description of Study Area

The Ormond Lake study area was located west of Saint John, New Brunswick in the Magaguadavic-Hillsborough Ecoregion (Loucks, O.L. 1961). Spruce was the predominant tree species on the study area with 1 017 merchantable stems per hectare and was intermixed with 205 merchantable stems per hectare of white birch, red maple and yellow birch (Betula alleghaniensic Britton). There were approximately 311 unmerchantable stems per hectare of small diameter trees and large cull trees. There were 145.8 m^3/ha of merchantable softwood and 32.6 m^3/ha of merchantable hardwood on the block. Branchiness was generally heavy with 31-50% of merchantable tree heights containing live branches. Slope on the block was predominantly adverse with 57% of the area in the 0-5% range, 20% in the 6-10% range, 16% in the 11-15% range, 5% in the 16-20% range, 1% in the 21-25% range and 1% in the 26+% range. The block was generally of Class 2 ground roughness and ground strength was good over a major portion of the area.

The soil consisted of rock and boulders covered by a shallow gravelly-loam and thin organic layer. Though most of the site was dry and well-drained, there were low portions bound by rock outcrops which were poorly drained. These areas were characterized by having a thick organic layer and wet soils. Generally, however the average depth of the organic layer was 10 cm.

Regeneration was very dense on the study area with an average of 62 150 softwood and 7 590 hardwood seedlings per hectare. Of the regeneration plots assessed 7% had neither softwood nor hardwood regeneration; 79% had softwood and 46% had hardwood seedlings. Most seedlings were less than 20 cm in height.

Harvest

The entire area was clearcut of all merchantable species using a combination manual/full-tree and manual/tree-length system. Softwood trees, which made up 81.7% of the total volume on the block, were manually felled and skidded in full-tree form to roadside by choker skidders. Full-tree softwoods were then mechanically delimbed and slashed at roadside into sawlogs and pulpwood. Hardwood trees were manually felled and topped at the stump, then were skidded in tree-length form to roadside by choker skidders. Tree-length hardwoods were then mechanically slashed into pulpwood at roadside by a portable slasher. A major portion of the block was harvested in the summer and fall of 1982 with weather conditions being good, both prior to and during the harvesting operation. Patches of residual wood were cleaned up in the summer of 1983.

Results

It was unfortunate that the post-harvest survey was conducted after a portion of the block was scarified and planted. The effects of the harvesting system could only be evaluated on 74 ha of the total 172 ha harvested. It will be interesting to compare the effects of the harvesting system on the site with the subsequent disturbance resulting from scarifying the area with chains and shark-fin barrels.

Roads and Landings

Roads and unbulldozed landings occupied 4.8% (8.2 ha) of the 172 ha block; 1.8% (3.1 ha) was bulldozed and 3.0% (5.1 ha) was occupied by piled wood or slash. There was approximately 2.5 km of road on the block and road plus landings averaged 33.0 m in width with 12.5 m of this being bulldozed.

Ground Disturbance on the Unbulldozed Cutover

Unscarified Portion

The percentage of the unbulldozed cutover area occupied by machine tracks and the percentage of area with organic and mineral layer disturbance are shown by slope class in Table 5. Landings were excluded from the estimates as they could not be properly sampled due to the heavy accumulation of slash. The percentage of area occupied by machine travel averaged 14% and remained relatively constant for slopes up to 15%. There were no machine tracks visible on slopes greater than 15%. Organic layer disturbance occurred on 21% of the area and though the disturbance was less in the 6-10% slope range, the general trend was that organic layer disturbance increased with increasing slope. Mineral layer disturbance occurred on only 2% of the area and though there was no disturbance on slopes from 6-20%, an increase in mineral layer disturbance did appear for slopes greater than 20%.

Scarified Portion

Accurate information on the portion of area occupied by machine tracks and the disturbance resulting from the harvesting system could not be obtained for that portion of the block that was scarified before the post-harvest survey was conducted. However, Table 6 indicates the amount of organic and mineral layer disturbance caused by the scarification equipment. Due to the dragging action of chains and shark-finned barrels there was a significant increase in the percentage of area with organic layer disturbance than on the unscarified portion of the block. Organic layer distur-

Table 5. Percentage of area occupied by machine tracks, organic layer disturbance and mineral layer disturbance on the unscarified portion of the Ormond Lake Study Area.

Degree of Disturbance	Slope % 0-5	6-10	11-15	16-20	21-25	26+	All Slopes
	% of cutover area						
PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
- Light	4	12	6	---	---	---	6
- Moderate	2	---	---	---	---	---	2
- Heavy	7	---	6	---	---	---	6
Total	13	12	12	---	---	---	14
PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
- Light	17	7	24	---	33	15	17
- Moderate	3	---	---	---	---	18	2
- Heavy	3	---	---	---	5	---	2
Total	23	7	24	---	38	23	21
PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
- Light	1	---	---	---	5	3	1
- Moderate	2	---	---	---	---	---	1
- Heavy	---	---	---	---	---	---	---
Total	3	---	---	---	5	3	2

bance occurred on 80% of the scarified area and a significant increase in the degree of disturbance was found as indicated by the 13% of the scarified area in the heavy organic layer disturbance classification. Mineral layer disturbance occurred on 10% of the scarified area and although this represented a substantial increase over the unscarified portion of the block the degree of disturbance was generally in the light to medium classification. Organic layer disturbance remained relatively constant for all slopes, however, mineral layer disturbance appeared to increase with increasing slope.

Table 6. Percentage of area occupied by organic layer disturbance and mineral layer disturbance on the scarified portion of the Ormond Lake Study Area.

Degree of Disturbance	0-5	6-10	11-15	16-20	21-25	26+	Slopes
	Slope %						
	% of cutover area						
PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
- Light	36	40	47	49	---	---	40
- Moderate	32	29	10	23	---	---	27
- Heavy	10	15	23	7	---	---	13
Total	78	84	79	79	---	---	80
PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
- Light	6	12	7	3	---	---	7
- Moderate	2	---	6	---	---	---	2
- Heavy	---	---	1	---	---	---	1
Total	8	12	14	3	---	---	10

Slash Dispersal on the Unbulldozed Cutover

Unscarified Portion

Slash on the unscarified portion of the unbulldozed cutover was estimated to be absent on 52%, light on 36%, moderate on 9% and heavy on 3% of the unscarified area. Very little slash remained on the block because of the full-tree harvesting operation. The 3% of area in the heavy classification occurred at roadside where there was an almost continuous concentration of heavy compacted slash in strips approximately 13.0 m wide on both sides of the road, often being greater than 2 m in depth.

Scarified Portion

Slash on the scarified portion of the unbulldozed cutover was estimated to be absent on 87%, light on 12% and moderate on 1% of the area. The continuous strips of roadside slash piles resulting from the full-tree logging system were bulldozed into concentrated piles randomly located at roadside. These slash piles were excluded from the survey due to the fact that the site under these piles could not be sampled because of the extreme height and physical bulk of the piles.

Post-Harvest Regeneration on the Unbulldozed Cutover[6]

Unscarified Portion

Following the harvesting operation it was estimated that there were 51 800 softwood and 200 hardwood seedlings per hectare in an undamaged or only slightly damaged condition, or 46% of the original softwood seedlings and 7% of the original hardwood seedlings. There were softwood seedlings in 57% and hardwood seedlings in 7% of the sample plots following harvesting. In 40% of the sample plots neither softwood or hardwood seedlings were present following the harvesting operation.

Scarified Portion

Following the harvesting operation and the subsequent scarification it was estimated that there were 3 500 softwood and 500 hardwood seedlings per hectare in an undamaged or only slightly damaged condition, or 14% of the original softwood seedlings and 5% of the original hardwood seedlings. There were softwood seedlings in 19% and hardwood seedlings in 6% of the sample plots following the harvesting operation and the subsequent scarification. On 76% of the sample plots neither softwood nor hardwood seedlings were present following harvesting and scarification.

---

[6] In the Description of Study Area section, the amount of regeneration was based on an average for the entire block; however, as post-harvest regeneration on the cutover has been analysed on the scarified and unscarified portion, the comparison to the original pre-harvest regeneration data is based on the following:

Unscarified Portion:

113 090	softwood stems/ha
3 350	hardwood stems/ha
92%	of plots contained softwood regeneration
32%	of plots contained hardwood regeneration
3%	of plots contained no softwood or hardwood regeneration

Scarified Portion:

24 080	softwood stems/ha
10 800	hardwood stems/ha
68%	of plots contained softwood regeneration
66%	of plots contained hardwood regeneration
11%	of plots contained no softwood or hardwood regeneration

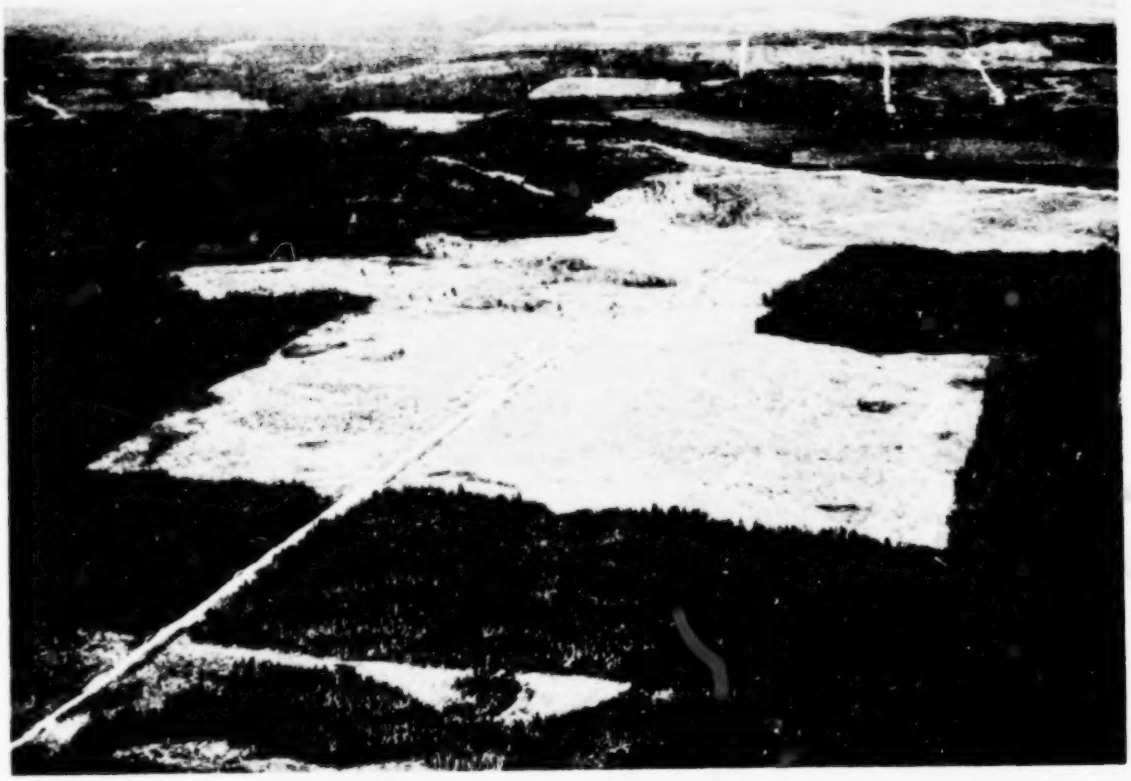


Figure 9.

Ormond Lake Study Area

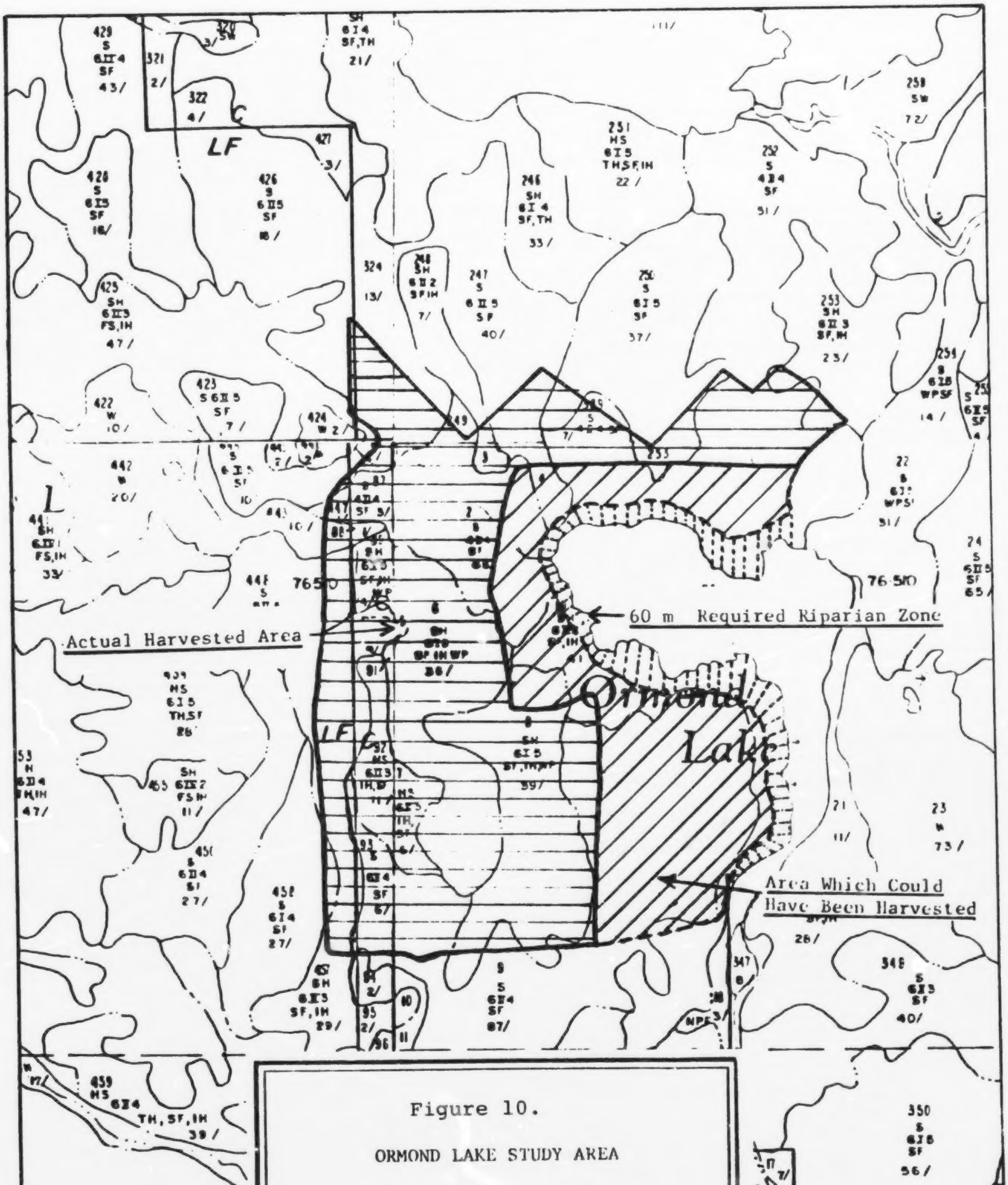

60 m Required Riparian Zone
Actual Harvested Area
Area Which Could Have Been Harvested
Ormond Lake
Ham Lake
LF
765.0
76.5/0

Figure 10.

ORMOND LAKE STUDY AREA

Scale - 1:20 000

Regeneration Potential on Unbulldozed Cutover

Unscarified Portion

Regeneration potential was assessed on a plot basis on the unscarified portion of the unbulldozed cutover with soil disturbance, slash accumulation and the natural condition of the site as the limiting factors. Using only soil disturbance as the limiting factor, regeneration potential was estimated to be not limited in 72%, moderately limited in 19% and severely limited in 9% of the plots. Using only slash accumulation as the limiting factor, regeneration potential was estimated to be not limited in 86%, moderately limited in 8% and severely limited in 6% of the plots. Using only the natural condition of the site as the limiting factor regeneration potential was estimated to be not limited in 83%, moderately limited in 9% and severely limited in 8% of the plots. Using soil disturbance, slash accumulation and/or the natural condition of the site, regeneration potential was estimated to be not limited in 64%, moderately limited in 21% and severely limited in 15% of the sample plots.

Scarified Portion

Regeneration potential was also assessed on the scarified portion of the unbulldozed cutover. Using soil disturbance as the limiting factor, regeneration potential was estimated to be not limited in 90%, moderately limited in 6% and severely limited in 4% of the sample plots. Using slash accumulation as the limiting factor, regeneration potential was estimated to be not limited in 85%, moderately limited in 10% and severely limited in 5% of the plots. Using the natural condition of the site as the limiting factor, regeneration potential was estimated to be not limited in 82%, moderately limited in 15% and severely limited in 3% of the plots. Using soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors, regeneration potential was estimated to be not limited in 74%, moderately limited in 17% and severely limited in 9% of the sample plots.

Erosion Potential on Unbulldozed Cutover

Unscarified Portion

Erosion potential was assessed on a plot basis for the unscarified portion of the unbulldozed cutover. Erosion potential was estimated to be low on 95%, medium on 3% and high on 2% of the area. The high classification occurred near the roadside landings where the skidders tended to do more manoeuvering over the same area while the medium classification occurred near skid-trails where the skidders made several passes over the same area.

Scarified Portion

Erosion potential was found to be low on 100% of the scarified portion of the unbulldozed cutover area, indicating that the degree of disturbance created by the shark-finned barrels and chains did not create severe gouging or scraping of the mineral layer sufficient enough to cause soil erosion and siltation.

Fibre Utilization

Merchantable waste volume averaged 4.32 m^3/ha on the cutover area excluding the continuous strips of slash at roadside on the unscarified portion and excluding the bulldozed mounds of slash resulting from the scarification on the other portion of the block. Most of the merchantable waste excluding the roadside slash piles was in the form of small diameter trees, usually less than 16 cm DBH, that were broken or dropped during the harvesting operation. There was also, to a lesser extent, merchantable waste left in the form of bolts and tops from breakage and long-butts caused by the chainsaw operator over-estimating the amount of butt rot in a tree. The concentrated strips of slash at roadside on the unscarified portion were not sampled due to the fact that when the post-harvest survey was carried out the pulpwood still remained at roadside. The mounds of slash piled on the scarified portion could not be sampled for merchantable waste due to the fact that the physical bulk of the piles made it too time consuming for them to be ripped apart. Total merchantable waste on the block excluding roadside landings was calculated to be 709 m^3 or approximately 2.81% of the 25 213 m^3 harvested on the block.[7]

The average stump height on the block was 9.9 cm and the average stump height diameter was 21.6 cm. The average height to diameter ratio was 0.530.

The average top diameter was 7.8 cm for softwood with a range from 6 to 12 cm and 10.7 cm for hardwood with a range from 4 to 22 cm.

A buffer strip of standing timber ranging from 125 m to 620 m in width was left between the harvested area and Ormond Lake as indicated in Figure 10. A combination of the 'straight-line' clearcut configuration and the intensity of the cutting in the area around Ormond Lake resulted in this excessive buffer strip being left. This riparian zone belt encompassing an area of 80 ha will in most likelihood not be harvested due to the fact that the adjacent study block has now been planted. Proper scheduling and block layout could have produced an additional 11 600 m^3 of merchantable fibre if this buffer strip could have been harvested.[8]

---

[7] The 25 213 m^3 is the actual volume of all primary forest products scaled on the block.

Discussion

Roads and Landings

Roads and landings occupied 4.8% of the block area which is within the allowable limit of 5% specified in the FMM. The concentrated strips of slash left at roadside would therefore not have to be dispersed or burned under the present requirements other than for aesthetic reasons. The average width of bulldozed area was 12.5 m which is within the 20 m required width specified in the FMM.

Ground Disturbance on the Unbulldozed Cutover

The apparent decrease in area occupied by wheel tracks on the unbulldozed cutover occurred on slopes greater than 15% because the steeper areas were avoided for machine maneouverability and safety reasons. The percentage of area occupied by organic layer disturbance was greater than the percentage of area occupied by machine tracks suggesting that the action of the full-trees being dragged over the thin organic layer may have done more damage than the wheel tracks. Organic layer disturbance was generally in the light classification. Areas classified as having heavy disturbance occurred near roadside landings or on skid trails where the choker skidders travelled over the same area several times. The action of full-trees being dragged over the organic layer as well as the wheel tracks accounted for much of the organic layer disturbance. Mineral layer disturbance was minimal with only 2% of the unbulldozed cutover area being disturbed. This disturbance was in the light to moderate classification. Although ground disturbance did appear to increase with increasing slope, the severity of this disturbance did not, as indicated by the greater disturbance in the light to moderate classifications. This could indicate that ground disturbance caused by this particular harvesting system is more closely related to the amount of machine travel than it is to slope. For this reason any attempt to reduce the severity of ground disturbance should be directed at reducing the number of machine passes over the same area.

---

[8] The 11 600 m^3 of merchantable fibre is based on the pre-harvest cruise data of the merchantable softwood volume on the adjacent block. Cover type maps indicated that the species composition of the riparian strip is almost exclusively softwood with a similar volume as that on the adjacent cutover area.

Ground disturbance caused by the use of chains and shark-finned barrels caused an increase in the percentage of area occupied by ground disturbance. Organic layer disturbance occurred on 80% of the scarified area and the severity of this disturbance increased such that 13% of the scarified area was in the heavy classification.

Mineral layer disturbance increased after scarification, however not to the extent of the organic layer disturbance, both in the amount of area disturbed and the severity of disturbance. This indicates that while breaking up and loosening much of the organic layer the chains and shark-finned barrels did not cause any great damage to the mineral layer.

Slash Dispersal on the Unbulldozed Cutover

Slash was virtually absent on most of the cutover because all softwood trees, which made up the most of the merchantable volume of the block, were skidded in full-tree form to roadside. While this caused a heavy concentration of slash at roadside, the area occupied by this slash was within the required limits of the FMM. The absence of slash on much of the block would facilitate any artificial reforestation efforts and slash should pose no barrier to advance regeneration. For this reason, it is quite questionable whether or not the scarification treatment prescribed for this site was really necessary. If the primary reason for scarification was to disperse the hardwood tops left on the site so as to provide little or no obstacles to the subsequent planting operation, the economics of such a silvicultural treatment seems unjustifiable.

Post-Harvest Regeneration on the Unbulldozed Cutover

There was a considerable reduction in the number of healthy seedlings on the block following the harvesting operation, however, substantial numbers of softwood seedlings still remained. The heavy attrition on the advanced hardwood regeneration during the harvesting operation could be attributed to the fact that the hardwood seedlings were of greater height and thus probably more susceptible to damage when the full-trees were dragged across the area. The number of plots with softwood regeneration dropped from 79% before harvest to 57% after harvest indicating that the 60% stocking level by natural regeneration may not be attainable. The action of the full-trees being dragged over much of the area probably caused much of the damage to the advanced regeneration.

A further reduction in the number of healthy seedlings occurred in that portion of the block that was scarified. Not only was there a significant reduction in the total number of seedlings but the number of plots with softwood regeneration dropped to 19% following scarification. The justification in scarifying this particular cutover after the full-tree harvesting operation could be questioned. The absence of slash over most of the area and the numbers of healthy spruce seedlings after harvest seem to warrant spot planting with a minimum amount of site preparation, however, such silvicultural prescriptions are beyond the scope of this report.

Regeneration Potential on the Unbulldozed Cutover

Using soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors, regeneration potential was estimated to be severely limited on 15% of the unbulldozed cutover area. Regeneration potential was severely limited on areas with exposed boulders and ledge. A combination of the harvesting system and the ground roughness of the site caused this exposure. The thin organic layer was easily stripped from the underlying layer of rock and boulders by the skidding action of the full-trees. The subsequent exposure of rock ledge and boulders causes irreparable damage to the area's capability of producing natural regeneration. Regeneration potential was also severely limited near or under roadside slash piles where the dense compacted slash inhibits the growth of natural regeneration.

Using slash accumulation, soil disturbance and/or the natural condition of the site as the limiting factors, regeneration potential was estimated to be severely limited on 9% of the scarified area compared to the 15% on the unscarified portion. Although slash dispersal and the redistribution of the torn-up organic layer enhances the regeneration potential, there is inherent danger that the destruction of the established softwood seedlings present before scarification and the disturbance and subsequent germination of an undesirable seed source may lead to an unacceptable species composition for the cutover area.

Erosion Potential on the Unbulldozed Cutover

With this particular combination of harvesting system and site, erosion and siltation would not be expected to be a problem. The 3% of the area in the medium classification and the 2% in the high classification occurred near skid-trails or landings where the skidders made several passes over the same area. The action of the wheels and the dragging of full-trees created some scraping of the mineral soil, however, on this particular site characterized by a shallow mineral and organic layer over rock and boulders severe ground disturbance was minimal. By reducing the number of machine passes over the same area the severity of ground disturbance could probably be further reduced.

Fibre Utilization

The average merchantable waste volume for the unbulldozed cutover area, excluding the roadside landings was 4.32 m^3/ha which exceeds the 3.0 m^3/ha requirement specified in the FMM. The greater portion of the merchantable waste (66%) was in the form of small diameter trees, usually less than 16 cm DBH, that were broken, dropped or simply knocked down during the harvesting operation.

There was no merchantable waste volume determined for the roadside slash piles due to the fact that the pulpwood still remained at roadside when the post-harvest survey was carried out. The slash piles were dense and compacted which made ripping them apart to measure every possible merchantable piece a time consuming task.

Merchantable waste in high stumps was minimal and generally stumps were cut below the 30 cm height requirement as specified in the FMM.

There is no actual topping diameter specified by regulation in New Brunswick, however, waste remaining in oversized tops is accounted for within the Merchantable Waste Volume Determination procedures in the FMM. The average top diameter of 7.8 cm for softwood and 10.7 cm for hardwood indicated that little waste resulted from premature topping; with the softwoods being better utilized than the hardwoods. However, the ranges of top diameters of up to 12 cm in softwood and 22 cm in hardwood indicate that some waste is occurring from oversized tops. Hardwoods were topped and delimbed at the stump and were generally topped when the first whorl of large branches was encountered. These larger diameter limbs were left on the cutover and resulted in the hardwood tops having an average diameter greater than the softwood tops.

The combination of the cutting intensity in the vicinity of the study area and the straight line clearcut configuration has isolated approximately 11 600 m^3 of merchantable fibre that in all likelihood will never be harvested unless additional roads are constructed through the adjacent planted cutovers. Proper block layout would have allowed this 80 ha to be harvested first while leaving the 83 ha west of the main logging for harvesting at a future date. This is of course speaking from a fibre-use point of view and wildlife considerations may warrant a change in this philosophy.

Suitability to Existing Forest Conditions

The manual/full-tree/tree-length harvesting system combined with the mechanical delimbing and slashing at roadside appeared to be well suited to the site on which it was operating. The major portion of the site was well-drained with few boggy areas and the ground strength was capable of supporting the harvesting equipment. The presence of boulders and ledge outcrops did impede vehicle travel but these obstacles were usually avoidable. Soil disturbance was minimal and the skidders were capable of operating on slopes up to 25% with some increase to the organic layer disturbance but little increase to the mineral layer disturbance.

Although there were considerably fewer seedlings present following the harvesting operation, large numbers of undamaged softwood seedlings still remained, however, a 60% stocking level may not be possible as indicated by the reduction in the number of plots with regeneration present.

The manual limbing and topping of the hardwoods did produce some slash on the site; however, a greater portion of the cutover was left slash free except at roadside.

Suitability for Harvesting Environmentally Sensitive Areas

Based on field observations and the results of the assessments made on this particular harvest block, it is the authors' opinion that the manual-fell/full-tree skidding system could be used to harvest, within acceptable environmental limitations, wood in riparian strips and deer yards.

The versatility of the choker skidder in the manual-fell/full-tree system makes it possible to use a variety of harvesting methods within riparian zones. Clear felling in the form of strips, patches or clearcuts as well as selective cutting could all be used with this particular harvesting method. Each riparian zone has its own characteristics and the type of harvesting method or combination of harvesting methods best suited for a particular area will depend on a number of site-related factors. Slope, ground roughness, bearing strength, stand density, size and condition of the wood and the width of the riparian zones are all factors which should be considered.

The choker skidders appeared to have little difficulty in negotiating slopes up to 25% provided that the ground roughness was such that obstacles which impeded their travel were avoidable. In a full-tree system, the choker skidder seems to have an advantage over the Koehring Feller Forwarder (KFF) and grapple skidder in that full-trees can be winched to the machine over rough or swampy ground. Thus, areas of poor ground bearing capacity may be harvested without severe ground disturbance. Although the manoeuverability of the choker skidder has an advantage over the KFF on steeper/rougher slopes, the skidding action of the full-trees across the site will probably cause an increase in ground disturbance.

Whichever harvesting method is chosen, areas of poor ground bearing capacity should be avoided. Since the severity of ground disturbance in a full-tree skidding system occurs on or beside skid-trails, minimizing the number of passes the skidder makes over the same area will reduce the disturbance and lower the subsequent erosion potential. Proper planning and cut layout in the riparian zone can minimize damage to the site and restrict harvesting in the more sensitive areas where disturbance may cause irreparable damage.

It would be beneficial from a production point of view to harvest within riparian zones where they are adjacent to a regular harvest block. Logging roads could be properly planned so that skidding distances would be similar to that on the adjacent cutover. The delimbing and slashing phase could also coincide with the operation in the adjacent cutover. The decision of whether or not to use the manual-fell/full-tree skidding system to harvest within the riparian zone should only be made as cutting progresses on the regular block and the effect the choker skidders are having on that particular site can be observed. When damage occurs on the regular block that is unacceptable for harvesting within the riparian zone, an alternative harvesting method within the riparian zone will have to be chosen.

Conclusions

The combination manual/full-tree and manual/tree-length skidding systems did not appear to cause any major problem on this particular site.

The area occupied by roads and landings was 4.8% which is within the allowed 5% required limit as outlined in the FMM.

Machine tracks occupied 14% of the unbulldozed area and organic and mineral layer disturbance occupied 21% and 2% respectively on the same unbulldozed area. Organic and mineral layer disturbance was generally in the light classification and although disturbance increased with increasing slope, the severity of this disturbance did not. A substantial increase in organic and mineral layer disturbance occurred after scarification but was generally in the light to moderate classification.

Slash on the block was estimated to be absent on 52%, light on 36%, moderate on 9% and heavy on 3% of the unbulldozed area. The 3% of area in the heavy classification occurred at roadside as a result of mechanical delimbing. Scarification did reduce slash accumulation in the moderate and heavy classification.

Regeneration potential was estimated to be not limited in 64%, moderately limited in 21% and severely limited in 15% of the sample plots. Regeneration potential was slightly enhanced after scarification.

Erosion potential was estimated to be low on 95%, medium on 3% and high on 2% of the area and erosion and siltation would not be expected to be a serious problem on this block. Erosion potential was estimated to be low on 100% of the area after scarification.

A considerable amount of advance regeneration was destroyed during the harvesting operation and only 46% of the original softwood seedlings and 7% of the original hardwood seedlings remained in an undamaged or slightly damaged condition. There was a reduction from 79% of plots with softwood regeneration prior to harvesting to 57% after harvesting. Although a considerable number of healthy softwood seedlings still remain, full stocking may not be attainable as indicated by the reduction in the number of plots with regeneration present following the harvesting operation. There was a drastic decrease in the amount of advanced regeneration following scarification.

There is a conflict between trying to reduce the soil disturbance and erosion by more uniformly distributing wheel tracks, and reducing advance regeneration damage by reducing the area occupied by wheel tracks. On areas where natural regeneration will be relied on to reforest the area an optimum approach could be, to reduce the area occupied by wheel tracks on areas of low erosion potential thus reducing the amount of damage to advance regeneration, and on areas of high erosion potential to operate the machine such that wheel tracks are more uniformly distributed, thus reducing the possibility of soil disturbance and erosion. On areas where natural regeneration will not be relied on to reforest the area the machine should be operated such that wheel tracks are uniformly distributed throughout the block.

Merchantable waste volume totalled 743 m^3 on the block and exceeded the 3.0 m^3/ha allowed by regulation. The greater portion of this waste was in the form of small diameter trees. An excessively wide buffer strip occupying approximately 80 ha was left between the cutover and Ormond Lake. Proper planning and block layout could have yielded approximately 11 000 m^3 of merchantable fibre from this riparian zone which in all likelihood may never be harvested.

With proper supervision and choice of site, the manual/full-tree system could be used to harvest riparian strips within acceptable environmental and economical constraints.

APPENDIX V

CRYSTAL LAKE STUDY AREA

An Evaluation of the Mechanical/Short-wood Harvesting System

CRYSTAL LAKE STUDY AREA

Description of Study Area

The Crystal Lake study area was located northeast of Saint John in the Magaguadavic-Hillsborough ecoregion (Loucks, O.L. 1961). Spruce was the predominant tree species on the study area with 782 merchantable stems per hectare and was intermixed with 166 merchantable stems per hectare of white birch, red maple and eastern white cedar. There were approximately 474 unmerchantable stems per hectare of small diameter trees and larger cull trees. There were 101.0 m^3/ha of softwood and 10.2 m^3/ha of hardwood on the block. The branchiness class was generally light with 31-50% of the merchantable height containing live branches. Slope on the block was predominantly favorable with 52% of the area in the 0-5% range, 16% in the 6-10% range, 20% in the 11-15% range and 12% in the 16-20% range. Ground bearing strength was predominantly good, however, there were patches of poorly drained, low lying areas where the organic layer was greater than 100 cm in depth. Ground roughness was variable throughout the block with 40% of the area Class 1 and 60% of the area Class 2. The soils in this ecoregion are generally shallow, gravelly-loam soils (Loucks, O.L. 1961) with the average organic layer depth being 15 cm excluding the swampy areas.

Regeneration was very dense on the study area with an average of 85 400 softwood and 20 200 hardwood seedlings per hectare. Of the regeneration plots assessed 4% had neither softwood nor hardwood regeneration; 96% had softwood seedlings and 58% had hardwood seedlings. Most seedlings were less than 15 cm in height.

Harvest

The area was clearcut of all merchantable species by a mechanical/short-wood system. Trees were felled and bunched along trails running parallel to each other by the Kockums 880 Feller Buncher. The Kockums Processor travelled up and down these trails delimbing and slashing the wood into logs and pulp which were picked up by short-wood forwarders and forwarded to roadside. Some hardwood was skidded to roadside in tree-length form and a small portion of the block was manually trail-cut. The majority of the cutting took place between January and March of 1983 with some clean up in August and September of the same year.

Results

Roads and Landings

Roads and bulldozed landings occupied 2.3% of the 88 ha block. There was approximately 1.5 km of road constructed on the block and the bulldozed width of road plus bulldozed landings averaged 13.5 m in width.

Ground Disturbance on the Unbulldozed Cutover

The percentage of unbulldozed cutover area occupied by machine tracks and the percentages of area with organic and mineral layer disturbance are shown by slope class in Table 7. Landings were excluded from the estimates because they could not be properly sampled due to the heavy accumulation of slash. The percentage of area occupied by machine travel averaged 26% and remained relatively constant for slopes up to 15%, however, a decrease appeared to occur on slopes above 15%. The percentage of area with organic layer disturbance appeared to follow the same trend. Organic layer disturbance occurred on 27% of the area, however, the severity of this disturbance did not appear to increase with slope. The percentage of area occupied by mineral layer disturbance averaged 2% with a significant increase on slopes in the 6-10% range. The severity of mineral layer disturbance did not appear to increase on slopes greater than 10%.

Slash Dispersal on the Unbulldozed Cutover

Slash on the unbulldozed cutover was estimated to be absent on 35%, light on 43%, moderate on 9% and heavy on 13% of the area. The mechanical/short-wood system produced continuous rows of slash evenly distributed over the entire block. The heavy accumulation of slash occurred when a number of trees were delimbed and topped on the same site. Slash accumulation in this category was often greater than one meter.

Post-Harvest Regeneration on the Unbulldozed Cutover

Following the harvesting operation it was estimated there were 52 500 softwood and 520 hardwood seedlings per hectare in an undamaged or only slightly damaged condition or 49% of the original softwood seedlings and only 3% of the original hardwood seedlings. There were softwood seedlings in 67% and hardwood seedlings in 13% of the sample plots following the harvesting operation. There was no softwood or hardwood regeneration found on 33% of the post-harvest sample plots.

Table 7. Percentage of area occupied by machine tracks, organic layer disturbance and mineral layer disturbance on the Crystal Lake Study Area

Degree of Disturbance	Slope %						
	0-5	6-10	11-15	16-20	21-25	26+	All Slopes
	% of cutover area						
PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
- Light	19	23	21	3	---	---	18
- Moderate	10	6	10	---	---	---	8
- Heavy	---	---	---	---	---	---	---
Total	29	29	31	3	---	---	26
PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
- Light	11	8	15	3	---	---	10
- Moderate	2	10	---	---	---	---	3
- Heavy	18	15	10	---	---	---	14
Total	31	33	25	3	---	---	27
PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
- Light	---	10	2	---	---	---	2
- Moderate	---	---	---	---	---	---	---
- Heavy	---	---	---	---	---	---	---
Total	---	10	2	---	---	---	2

Regeneration Potential on the Unbulldozed Cutover

Regeneration potential was assessed on a plot basis on the unbulldozed cutover including unbulldozed landings and was assessed based on soil disturbance, slash accumulation and the natural condition of the site as the limiting factors. Using only soil disturbance as the limiting factor, regeneration was estimated to be not limited in 30%, moderately limited in 48%, and severely limited in 22% of the plots. Using only slash accumulation as the limiting factor, regeneration potential was estimated to be not limited in 29%, moderately limited in 50% and severely limited in 21% of the plots. Using only the natural conditions of the site as the limiting factor, regeneration potential was estimated to be not limited in 23%, moderately limited in 45% and severely limited in 32% of the plots.

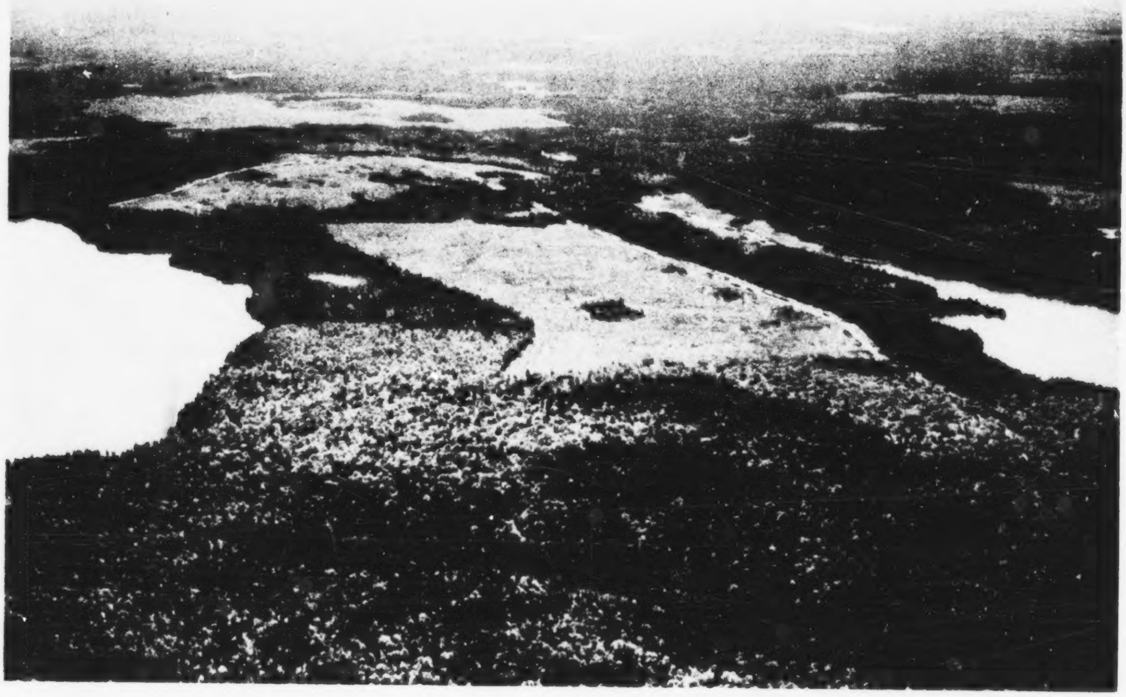


Figure 11.

Crystal Lake Study Area

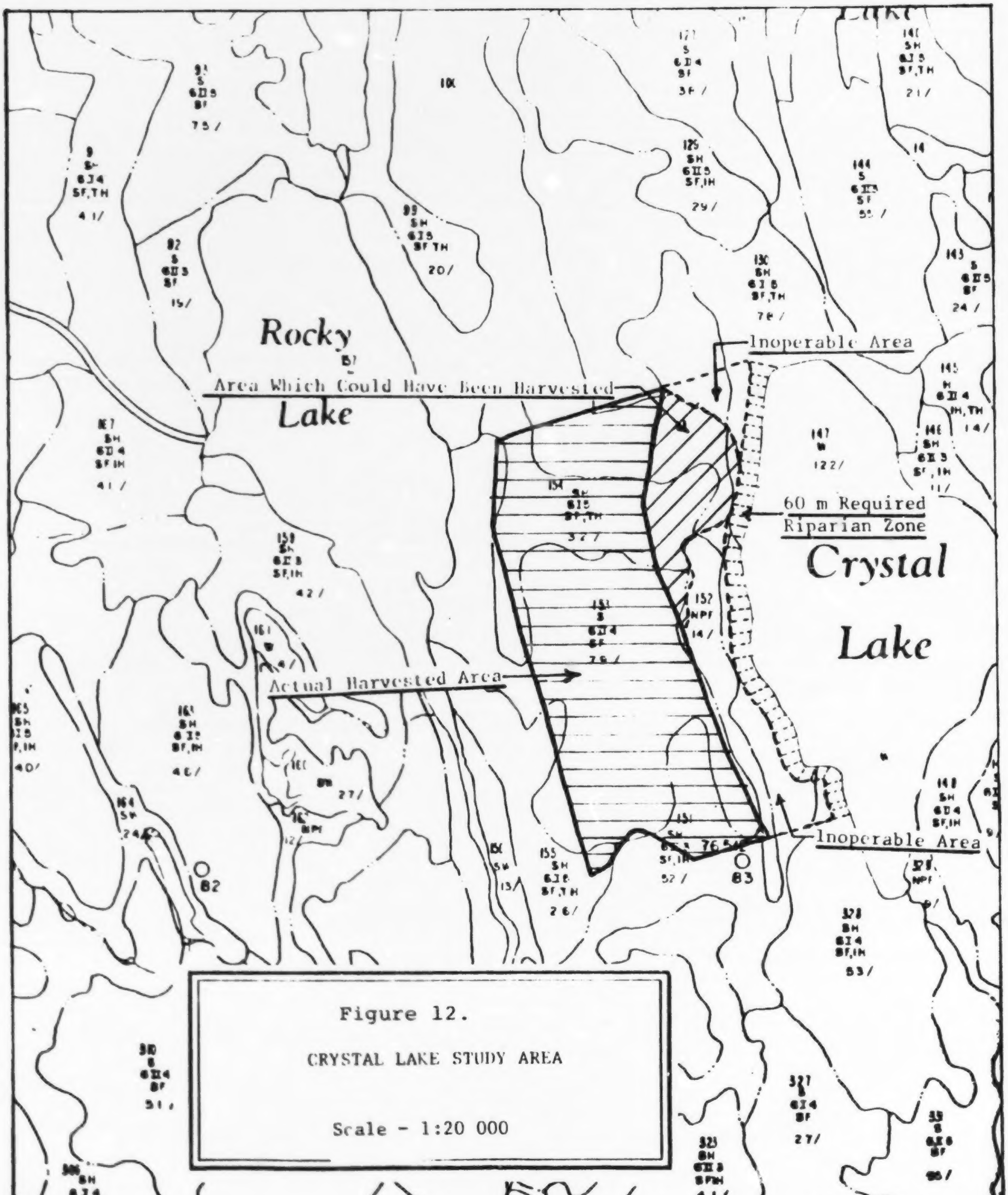


Figure 12.

CRYSTAL LAKE STUDY AREA

Scale - 1:20 000

Erosion Potential on the Unbulldozed Cutover

Erosion potential was assessed on a plot basis for the unbulldozed portion of the cutover. Erosion potential was estimated to be low on 96% and medium on 4% of the plots. The area in the medium classification occurred on slopes in the 16-20% range and on plots adjacent to windrows of slash where the off-road processor was positioned.

Fibre Utilization

Merchantable waste volume averaged 2.66 m^3/ha on the entire block and 2.58 m^3/ha on the cutover area, excluding slash piles. Slash piles were not sampled separately but samples that fell entirely within these slash piles indicate there was approximately 4.48 m^3/ha of merchantable waste on these areas. Of the area sampled 75.0% of the plots had some waste and 25.0% of the plots had no waste. Waste in merchantable trees accounted for 73% while top and bolts accounted for 21% of the total merchantable waste volume on the entire block. Total merchantable waste on the block was calculated to be 234 m^3 or approximately 1.6% of the 14 871 m^3 harvested.[9]

The average stump height on the block was 17.3 cm and the average stump diameter was 21.9 cm. The average height to diameter ratio was 0.876.

The FMM states that the minimum horizontal buffer strip width for bank slopes greater than 10% should be 60 m. The actual riparian strip left on the northwest corner of the block averaged approximately 360 m to Crystal Lake. This extra width of riparian zone occupied 16 ha and could have produced 1 780 m^3 of wood without having to operate within the approved lake reserve.

In total the block could have produced an additional 2 014 m^3 of wood by eliminating merchantable waste and cutting the block to within 60 m of Crystal Lake.

Discussion

Roads and Landings

Roads and bulldozed landings occupied 2.3% of the total block area which is within the allowable limit of 5% as outlined in the FMM. The bulldozed landings were an extended width of the logging road allowing for the merchantable wood, in short-wood form, to be piled along the road. The average width of bulldozed area was 13.5 m which is within the 20 m required width as outlined in the FMM.

---

[9] The 14 871 m^3 is the actual volume of all primary forest products scaled on the block.

Ground Disturbance on the Unbulldozed Cutover

The apparent decrease in area occupied by wheel tracks on the unbulldozed cutover occurred on slopes greater than 15% suggesting that the steeper slopes were avoided for machine maneouverability and safety reasons. Although the short-wood forwarders are capable of working on slopes greater than 15%, they were restricted to follow in the same path as the less maneouverable Kockums Processor. Machine travel did cause damage to the organic layer in that 27% of the area was disturbed in comparison to the 26% of the area occupied by wheel tracks. The severity of organic layer disturbance did not increase with increasing slope but seemed to be more dependent on the number of machine passes made over the same area. Because of the trail-cut harvesting method the feller/buncher, delimber/slasher and the short-wood forwarder generally all used the same track in moving along each trail, with the forwarders sometime making several passes over the same tracks. The numerous passes by these machines caused heavy organic layer disturbance on 14% of the cutover area. Machine travel, however, caused little damage to the mineral layer in that only 2% of the area was disturbed in comparison to the 26% of the area occupied by the wheel tracks. Mineral layer disturbance was light and did not appear to increase with increasing slope. Although most of the block was harvested during the winter season, snowfall depth during that time was not sufficient enough to protect the organic layer from disturbance. However, the frozen ground did seem to protect the mineral layer from any disturbance. Reducing the number of machine passes over the same area could reduce the severity of ground disturbance, however, this would be quite difficult using this trail-cut harvesting method.

Slash Dispersal on the Unbulldozed Cutover

The mechanical/short-wood harvesting system employed on this block produced continuous rows of slash distributed over the entire block. This resulted in 9% of the unbulldozed area in the moderate slash accumulation classification and 13% in the heavy classification. As a result regeneration potential was severely limited on 21% of the area. This means that without some form of effective slash disposal 18.3 ha may be taken out of production for possibly one or more rotations. Slash was estimated to be absent or light on 78% of the total area posing no barrier to advanced regeneration growth or reforestation efforts.

Post-Harvest Regeneration on the Unbulldozed Cutover

There was a considerable reduction in the number of healthy seedlings on the block following the harvesting operation, however, substantial numbers still remain. The number of plots with softwood regeneration dropped from 96% before harvest to 67% after harvest, indicating that the 60% stocking level by natural regeneration can be achieved. Most of the advanced regeneration damage on the block was caused by wheel tracks from the various harvesting equipment used. Although cutting occured during the winter months, insufficient snow cover failed to protect the seedlings as might have been expected. The uniform distribution of the trails and machinery over the cutover is a characteristic of this type of harvesting system and it is unlikely that an effective reduction in the area occupied by the wheel tracks or reducing the number of machine passes over the same area can be achieved without drastically changing the harvesting method.

Regeneration Potential on the Unbulldozed Cutover

Using soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors, regeneration potential was estimated to be severely limited on 33% of the area following the harvesting operation. This area which represents approximately 29 ha may be incapable of producing a vigorous stand of timber within one rotation period unless some form of silviculture treatment is initiated. Reducing the severity of organic layer disturbance by reducing the number of passes a machine makes over the same area would enhance regeneration potential, however, as mentioned earlier, this would be difficult to achieve with this particular harvesting method.

Erosion Potential on the Unbulldozed Cutover

With this combination of harvesting machinery and site, erosion and siltation would not be expected to be a problem, as 96% of the area was classified as having a low erosion potential and only 4% was classified as having a medium erosion potential. However, it must be remembered that this site was well-drained, had good ground bearing capacity and slopes did not exceed 20%. Erosion potential could increase on sites characterized by poor ground strength and increased slope, particularly using this mechanical harvesting system.

Fibre Utilization

Merchantable waste volume averaged 2.66 m^3/ha for the entire block which meets the 3.0 m^3/ha requirement in the FMM. The greater portion of this merchantable waste was in the form of small diameter trees knocked down by the Kockums

880 during the felling phase of the harvesting operation. Some small diameter trees buried within bunches along the trails might have been missed by the delimber/slasher. Merchantable waste in tops resulting from premature topping by the delimber/slasher was minimal.

Stumps were generally cut low, with the larger diameter trees often being cut flush with the ground by the shear. Many of the higher stumps occured in the smaller diameter classes where operators did not take time to position the shear for proper felling. The positioning of the felling head on the tree, while maneouvering around rock and boulders, produced slightly higher stumps.

An additional 1 780 m^3 of fibre could have been harvested if the northwest corner of the block was extended to include the area between the actual cut and the 60 m riparian zone required around Crystal Lake. The site characteristics of this 16 ha area were very similar to the actual block with the maximum slope being no greater than the maximum slope found on the harvested site. Without the construction of additional extraction roads, this area in all likelihood will never be cut. Proper block layout is essential so that all merchantable timber accessible at the time of harvest within a particular area can be removed.

Suitability to Existing Forest Conditions

The mechanical/short-wood operation appeared to cause no major damage to the capacity of the area to produce a future vigorous stand of timber. The site for the most part was well-drained and the ground bearing capacity suited the equipment used on the block. Ground roughness was such that some obstacles did impede vehicle travel but were usually avoidable. Machine tracks did cause some damage to the organic layer but mineral layer disturbance was minimal. The harvesting equipment was capable of operating on slopes up to 20% with no increase in soil disturbance. Although there were considerably fewer seedlings present following the harvesting operation the number of healthy seedlings remained in adequate numbers. However, the area is still likely to meet a 60% stocking level. Regeneration potential was surprisingly low and all three factors; soil disturbance, slash accumulation and the natural condition of the site limited the capacity of the area to regenerate naturally. Although the block was harvested during the winter season, organic layer disturbance and damage to the natural regeneration were caused by insufficient snow cover. A greater amount of damage probably would have been caused if the block was harvested during the summer or fall seasons.

Suitability for Harvesting Environmentally Sensitive Areas

It is difficult to judge whether or not the mechanical system used on this particular area would be suited for harvesting wood in riparian strips and deer yards. Certainly this system works best when large areas can be cleared with room for maneouvering the feller/buncher, delimber/slasher and short-wood forwarders. Selective cutting in riparian zones would not be practicable with this type of harvesting system. The mechanical/short-wood system is better suited for harvesting in strips, patches or larger clearcuts. The site should be of good ground bearing capacity with few springs; where the ground strength will not support the machines, severe ground disturbance will result. The feller/buncher, delimber/slasher and short-wood forwarders had little difficulty working on moderate slopes. They may be limited (especially the delimber/slasher) on slopes greater than 20%.

The width and slope of the riparian zone would determine the orientation of the cut strips. Wide riparian zones, which would normally be associated with steeper slopes, would probably have cut strips oriented at right angles to the watercourse, while narrow riparian zones which would normally be associated with more gradual slopes would probably have the cut strips oriented parallel to the watercourse.

In most cases the harvesting system would only be used to harvest in riparian strips where they are adjacent to a regular harvest block. The decision of whether to use this system to harvest within the riparian zone should only be made as cutting progresses on the regular block and the effect these machines are having on that particular site can be observed. When damage occurs on the regular block that is unacceptable for harvesting within riparian zones, an alternative harvesting method within the riparian zone will have to be chosen.

Conclusions

The mechanical/short-wood harvesting system did not appear to cause any major problem on this particular site. There was some damage to the organic layer and regeneration potential was surprisingly low since the block was harvested during the winter months.

Roads and bulldozed landings occupied 2.3% of the total harvested area which is within the allowed 5% required limit as outlined in the FMM.

Machine tracks occupied 26% of the unbulldozed cutover area and organic and mineral disturbance occupied 27%

ance was heavy on 13% of the area while mineral layer disturbance was in the light classification. The percentage of area disturbed as well as the severity of that disturbance did not increase with increasing slope.

Slash on the block was estimated to be absent on 35%, light on 43%, moderate on 9% and heavy on 13% of the unbulldozed area. The 13% in the heavy classification occurred when a large number of trees were delimbed and topped at a concentrated area.

Regeneration potential was estimated to be not limited on 13%, moderately limited on 54% and severely limited on 33% of the plots when using either soil disturbance, slash accumulation and/or the natural condition of the site as the limiting factors.

Erosion potential was estimated to be low in 96% and medium in 4% of the plots. Erosion and siltation would not be expected to be a serious problem on this block.

A considerable amount of advance regeneration was destroyed during the harvesting operation and only 49% of the original softwood seedlings remained in an undamaged or slightly damaged condition. There was a reduction from 96% of plots with softwood regeneration prior to harvest to 67% following the harvesting operation. Sufficient numbers of softwood seedlings remain, and a 60% stocking level should be attained.

There is a conflict between trying to reduce soil disturbance and erosion by more uniformly distributing machine tracks, and reducing advance regeneration damage by reducing the area occupied by machine travel. In a mechanized trail-cut operation such as this the distribution of area occupied by the feller buncher, delimber slasher and shortwood forwarder was quite uniform. It would be difficult to reduce the amount of advanced regeneration damage on this particular site with this type of harvesting system. The areas with the most severe ground disturbance occurred on or near machine tracks where numerous passes by all three machines took place.

The uniform distribution of these skid trails would reduce the severity of disturbance, however, restricted by boulders, rock outcrops and areas of poor bearing strength the grapple skidder operator was constrained to use the same trail for numerous passes. On a better quality site, with fewer obstacles, a uniform distribution of skid trails could be achieved reducing the severity of ground disturbance.

Merchantable waste volume totalled 234 m^3 on the block but did not exceed the 3.0 m^3/ha allowed by regulation. Most of the waste was in the form of small diameter trees left on the ground after harvest. Proper block layout and harvesting to those boundaries could have produced an additional 1 780 m^3 of merchantable wood.

This mechanical/short-wood system would have its limitations in harvesting riparian strips under acceptable environmental and economical constraints. Certainly on selected sites with proper planning and supervision this system would be feasible. However, realizing the damage to advance regeneration and the accumulation of slash, some effective form of slash dispersal and artificial reforestation may be required on some sites to attain a 60% stocking level.

APPENDIX VI

BAYLES LAKE STUDY AREA

An Evaluation of the Mechanical/Full-tree
Harvesting System

BAYLES LAKE STUDY AREA

Description of Study Area

The Bayles Lake study area was located west of Newcastle in the New Brunswick Highlands ecoregion (Loucks, O.L. 1961). Balsam fir and spruce were the predominant tree species on the study area with 853 merchantable stems per hectare intermixed with 234 merchantable stems per hectare of white birch and red maple. There were approximately 400 unmerchantable stems per hectare of small diameter trees and larger cull trees. There were 121.1 m^3/ha of softwood and 23.2 m^3/ha of hardwood on the block. Branchiness was generally heavy with 31 - 50% of merchantable tree heights containing live branches. Slope on the block was predominantly adverse with 42% of the area in the 0 - 5% range; 24% in the 6 - 10% range, 23% in the 11 - 15% range, 6% in the 16 - 20% range, 0% in the 21 - 25% range and 5% in the 26+% range. The entire block was of Class I ground roughness and ground strength was Class 2. The soils in this ecoregion are generally stony, sandy loams (Loucks, O.L. 1961). Regeneration was very dense in the study area with an average of 152 000 softwood seedings and 20 000 hardwood seedlings per hectare. Of the regeneration plots assessed 2% had neither softwood nor hardwood regeneration; 97% had softwood seedlings and 84% had hardwood seedlings. Most seedlings were less than 20 cm in height.

Harvest

The entire area was clearcut of all merchantable species by a mechanical/full-tree system. Trees were felled and forwarded to roadside by a Koehring Feller Forwarder (K.F.F.), delimbed at roadside by a sliding-boom delimber and slashed at roadside into sawlogs, veneer bolts and pulpwood by a portable slasher. Harvesting took place in early fall of 1982 with weather conditions being good, both prior to and during the harvesting phase.

Results

Roads and Landings

Roads and unbulldozed landings occupied 9.9% (9.4 ha) of the 94.9 ha block; 3.5% (3.3 ha) was bulldozed and 6.4% (6.1 ha) was occupied by piled wood or slash. There was approximately 2.0 km of road on the block and road plus landings averaged 48.0 m in width with 17.0 m of this being bulldozed.

Ground Disturbance on the Unbulldozed Cutover

The percentage of unbulldozed cutover area occupied by machine tracks and the percentages of area with organic and mineral layer disturbance are shown by slope class in Table 8. Landings were excluded from the estimates due to the heavy accumulation of slash. The percentage of area occupied by machine travel averaged 38% and remained relatively constant for slopes up to 20%, however a decrease appeared to occur for slopes above 20%. The percentage of area with organic and mineral layer disturbance appeared to follow the same trend. Organic layer disturbance occurred on 17% of the area and mineral layer disturbance occurred on 5% of the area. The severity of disturbance did not appear to increase with increasing slope.

Table 8. Percentage of area occupied by machine tracks, organic layer disturbance and mineral layer disturbance on the Bayles Lake Study Area.

	Slope %						
Degree of Disturbance	0-5	6-10	11-15	16-20	21-25	26+	All Slopes
	% of cutover area						
PERCENTAGE OF AREA OCCUPIED BY MACHINE TRACKS							
- Light	17	18	34	28	-	4	21
- Medium	14	9	6	7	-	2	10
- Heavy	6	14	2	-	-	2	7
TOTAL	37	41	42	35	-	8	38
PERCENTAGE OF AREA OCCUPIED BY ORGANIC LAYER DISTURBANCE							
- Light	10	10	8	12	-	3	9
- Medium	8	5	3	-	-	2	5
- Heavy	-	7	1	-	-	2	3
TOTAL	18	22	12	12	-	7	17
PERCENTAGE OF AREA OCCUPIED BY MINERAL LAYER DISTURBANCE							
- Light	2	-	1	-	-	1	1
- Medium	3	-	-	-	-	2	1
- Heavy	-	7	-	-	-	-	3
TOTAL	5	7	1	-	-	3	5

Slash Dispersal on the Unbulldozed Cutover

Slash on the unbulldozed cutover was estimated to be absent on 10%, light on 80%, moderate on 5% and heavy on 5% of the area. Very little slash remained on the block because of the full-tree harvesting operation. The 5% of area in the heavy classification was all at roadside. This slash was extremely heavy, compacted and concentrated in an almost continuous 13.0 m wide strip along both sides of the road, often being 2 to 3 m in depth.

Post-Harvest Regeneration on the Unbulldozed Cutover

Following the harvesting operation it was estimated there were 62 000 softwood and 1 000 hardwood seedlings per hectare in an undamaged or only slightly damaged condition, or 41% of the original softwood seedlings and 5% of the original hardwood seedlings. There were softwood seedlings on 90% and hardwood seedlings on 15% of the sample plots following harvesting.

Regeneration Potential on the Unbulldozed Cutover

Regeneration potential was assessed on a plot basis on the unbulldozed cutover, including the unbulldozed landings and was assessed based on both soil disturbance and slash accumulation as the limiting factors. Using only soil disturbance as the limiting factor, regeneration potential was estimated to be not limited in 98% and moderately limited in 2% of the plots. Using only slash accumulation as the limiting factor, regeneration potential was estimated to be not limited in 95%, and severely limited in 5% of the plots. The area in the severely limited regeneration potential classification occurred under the deep and compacted slash piles created at roadside by the mechanical delimbers. Using either soil disturbance and/or slash accumulation as the limiting factor, regeneration potential was estimated to be not limited in 93%, moderately limited in 2% and severely limited in 5% of the plots.

Erosion Potential on the Unbulldozed Cutover

Erosion potential was assessed on a plot basis only for the unbulldozed cutover. Erosion potential was estimated to be low in 95% and medium in 5% of the area. The area in the medium classification occurred where the machine made several passes over the same area in travelling to and from the landings or on slopes greater than 26%.

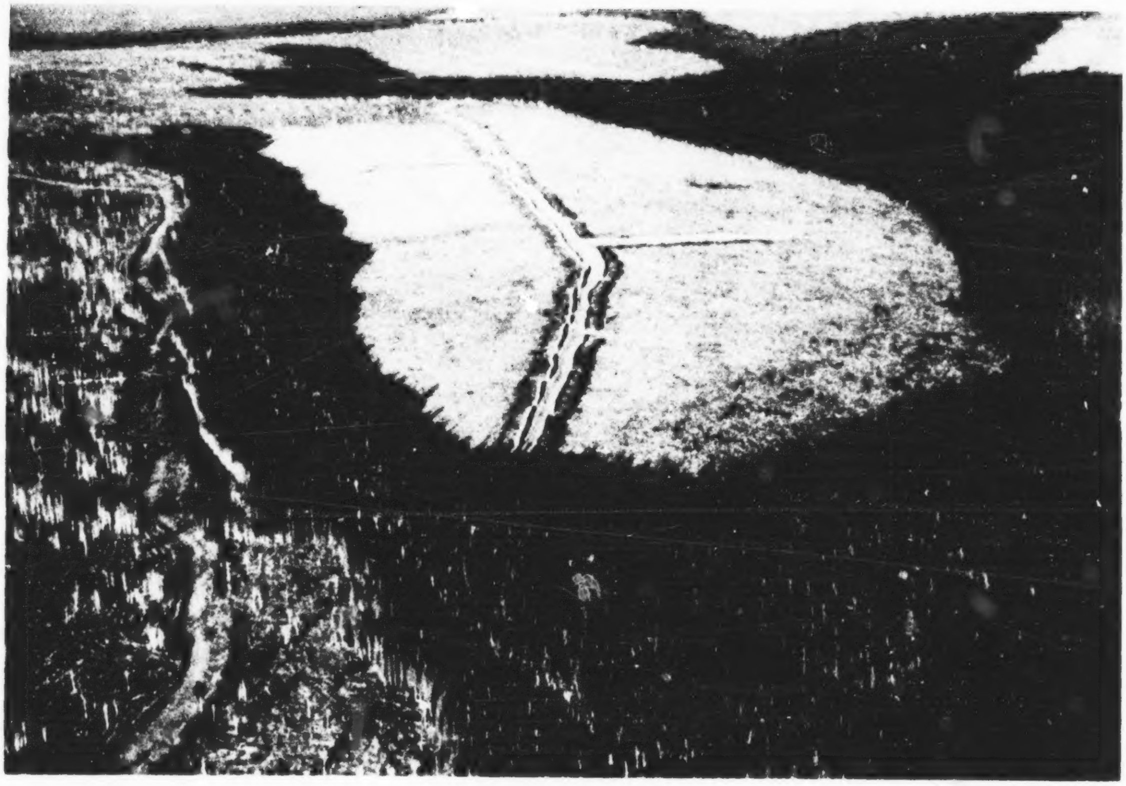


Figure 13.

Bayles Lake Study Area

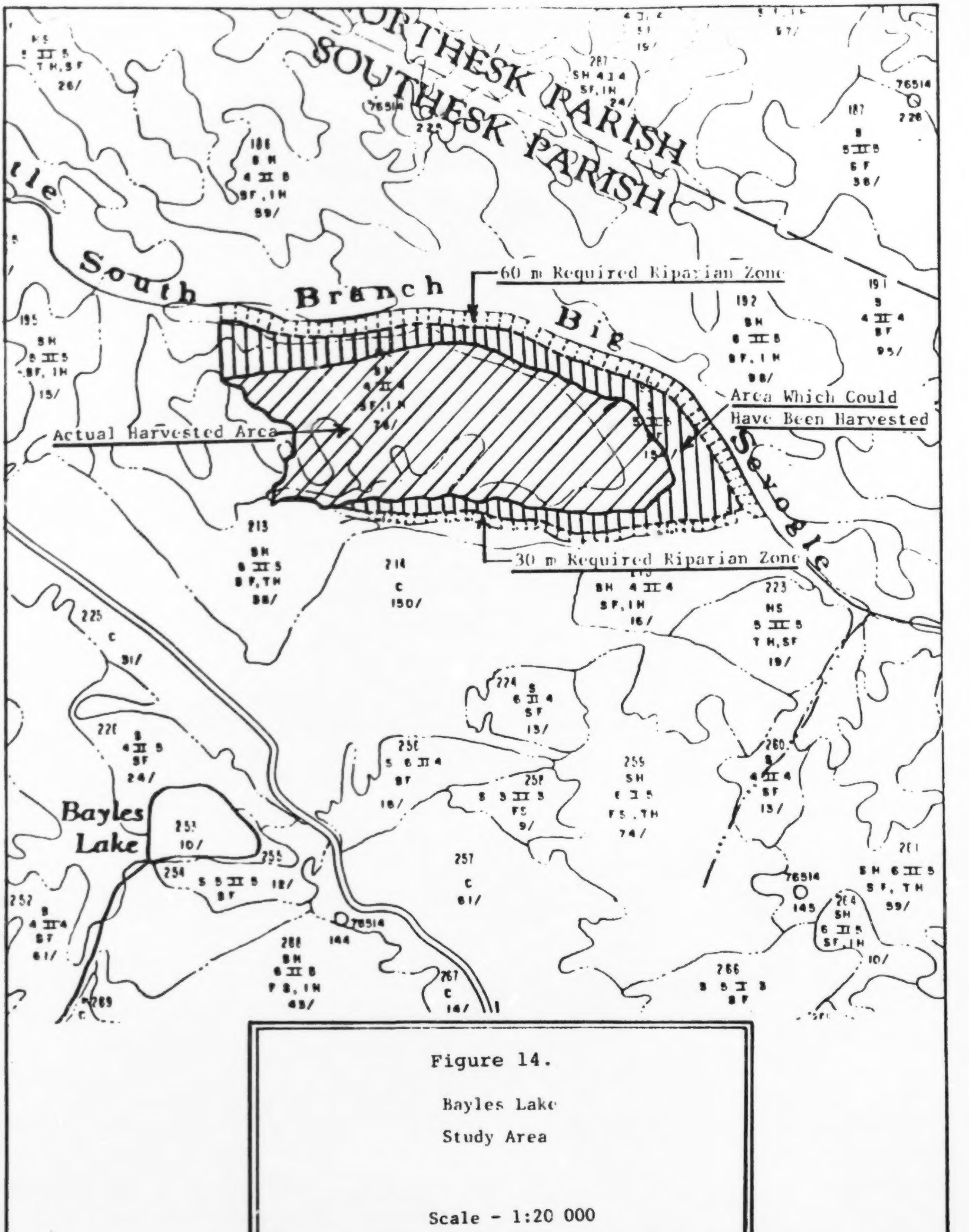

NORTHESK PARISH
SOUTHESK PARISH
South Branch Big Sevogle
60 m Required Riparian Zone
Area Which Could Have Been Harvested
Actual Harvested Area
30 m Required Riparian Zone
Bayles Lake

Figure 14.

Bayles Lake
Study Area

Scale - 1:20 000

Fibre Utilization

Merchantable waste volume averaged 4.63 m^3/ha on the entire block and 3.92 m^3/ha on the cutover area excluding the slash pile at roadside. Roadside slash piles were not sampled separately but the samples that fell entirely within these slash piles indicate that there was approximately 25 m^3/ha of merchantable waste on these areas. Waste in roadside slash piles was from trees broken or buried during the delimbing process. Long butts from the slashing process also accounted for some waste. Total merchantable waste on the block was calculated to be 440 m^3 or approximately 3.0% of 14 505 m^3 harvested on the block.[10]

The average stump height on the block was 11.3 cm and the average stump height diameter was 16.9 cm. The average height to diameter ratio was 0.776.

The average top diameter was 7.6 cm for softwood with a range from 4 to 16 cm and 8.8 cm for hardwood with a range from 4 to 32 cm.

A 30 m stream reserve was approved by the Department of Natural Resources to be left along all streams within the block, however average reserve width after harvesting was 133 m. This extra width of reserve occupied 45 ha and could have produced 6 500 m^3 of wood without having to operate within the approved stream reserve.

In total the block could have produced an additional 6 950 m^3 of wood by eliminating merchantable waste and cutting the entire approved area of the block.

Discussion

Roads and Landings

Roads and landings occupied 9.9% of the block area which is approximately double the 5% requirement allowed under the harvesting rules described in the FMM. Without any form of slash disposal approximately 10% of the area will be lost to forest production. As bulldozed areas only occupy 3.5% of the area the harvesting requirements under the FMM could be met by proper slash disposal. The heavy concentration of slash on the landings poses a difficult problem in restoring these areas to a tree-producing capability. A solution may be to bulldoze the compacted rows into a series of loose piles to allow a fire to penetrate, resulting in a more complete burn.

---

[10] The 14 505 m^3 is the actual volume of all primary forest products scaled on the block.

Ground Disturbance on the Unbulldozed Cutover

The apparent decrease in area occupied by wheel tracks on the unbulldozed cutover occurred on slopes greater than 20% because the steeper areas were avoided for road and landing construction, and for machine maneuverability and safety reasons. Most of the soil damage was caused by wheel tracks with only small amounts being caused by the machine knocking over unmerchantable trees. Machine travel did not necessarily cause damage to the organic or mineral layer as indicated by the organic and mineral layers being disturbed on only 17% and 5% of the area respectively as compared to the 38% of area being occupied by wheel tracks. One pass of the machine in most cases did not cause any ground disturbance other than to compress the organic layer. Disturbance was generally in the light and medium classifications. Areas classified as having heavy disturbance generally occurred where the machine travelled over the same route several times while moving to and from the landing areas. The severity of the disturbance did not appear to increase with slope and could indicate that the degree of disturbance is more closely related to the amount of machine travel than it is to the slope on which the machine is operating. For this reason, any attempt to reduce the severity of ground disturbance should be directed at reducing the number of passes over the same area.

Slash Dispersal on the Unbulldozed Cutover

Slash was virtually absent on most of the block because trees were mechanically delimbed at roadside. This caused a very heavy concentration of compacted slash, in an almost continuous strip along both sides of the road. Without some form of effective slash disposal, the 5% of area occupied by heavy slash or 4.7 ha will be taken out of production for possibly one or more rotations. The loss of this proportion of area will amount to a substantial loss of productive forest land in the Province. The absence of slash on most of the block would facilitate any reforestation efforts by planting and slash should pose no barrier to advance regeneration.

Post-Harvest Regeneration on Unbulldozed Cutover

There was a considerable reduction in the number of healthy seedlings following the harvesting operation, although a sufficient number still remain to regenerate the site. The large reduction in hardwood seedlings is thought to be due to the difficulty in locating the seedlings after leaf fall and may not be a true indication of the number of hardwood seedlings remaining. Although the number of plots with softwood regeneration dropped from 97% before harvest to 90% after harvest, this reduction should not hinder the ability of the area to regenerate naturally. There are sufficient numbers of softwood seedlings remaining. Slash is virtually absent over much of the cutover and overall natural regeneration potential is high. The damage to the softwood seedlings during the harvesting operation was caused by the K.F.F.'s wheels. Any attempt to improve the survival of advance regeneration should be directed at reducing the area occupied by the wheel tracks. Unnecessary manoeuvering of the K.F.F. should be restricted or eliminated.

Regeneration Potential on the Unbulldozed Cutover

Soil disturbance appeared to have very little detrimental affect on the ability of the area to be regenerated and areas that were judged to have any detrimental affect were located where machines repeatedly travelled over the same area. Any attempt to reduce the affects of soil disturbance on regeneration potential should be directed at restricting machine travel over the same ground more than once or twice. However, any attempt to reduce the effects of soil disturbance on regeneration potential by more evenly distributing the wheel tracks and thus reducing travel over any one location should be carefully weighed against the loss of advance regeneration due to machine damage.

Erosion Potential on the Unbulldozed Cutover

With this particular combination of machine and site, erosion and siltation would not be expected to be a problem, as 95% of the area was classified as having a low erosion potential and only 5% was classified as having a medium erosion potential. However, it must be remembered that this site was exceptionally good with respect to ground bearing capacity and this machine could have considerably different results on areas with poorer ground bearing capacities. Erosion potential increases with increased ground disturbance and slope. Therefore, repeated travel over the same area should be avoided especially on the steeper slopes.

Fibre Utilization

Average merchantable waste volume of 4.63 m^3/ha exceeds the 3.0 m^3/ha allowable under the requirements of the FMM. Most of the merchantable waste on the cutover, excluding the roadside slash piles, was in the form of small diameter trees, usually less than 14 cm, that were broken or dropped during the harvesting operation. Machine operators often did not harvest the small diameter dead trees with the bark starting to fall off even though the fibre in these trees was merchantable.

The heaviest concentration of merchantable waste was found in the roadside slash piles. Premature topping, breakage, burying of trees in the slash and long butting during the delimbing and slashing phases accounted for most of the waste. With proper supervision this type of waste could have been avoided.

Stumps were generally cut low, with the larger diameter trees often being cut flush with the ground by the shear. Many of the higher stumps occurred in the smaller diameter classes where operators did not take time to position the shear for proper felling.

There is no actual topping diameter specified by regulation in New Brunswick. However, waste remaining in oversized tops is accounted for within the Merchantable Waste Volume Determination procedures of the FMM. The average top diameter of 7.6 cm for softwood and 8.8 cm for hardwood indicate that little waste resulted from premature topping; with the softwoods being slightly better utilized than the hardwoods. However, the ranges of top diameters of up to 16 cm in softwood and 32 cm in hardwood indicate that some waste is occurring from oversized tops. There was difficulty delimbing hardwood trees with oversized limbs, subsequently, some hardwood trees were topped before the first fork, accounting for most of the waste in tops. The volume of wood lost by premature topping of some hardwoods was small because of the low percentage of hardwood trees on this block.

An additional 6 500 m^3 of fibre could have been harvested if the entire approved area had been cut. The 45 ha of approved but uncut block amounted to 47% of the area that was actually harvested. There appears to have been no site-related reason for not harvesting the area as both sites were very similar and maximum slope on the unharvested area was no greater than the maximum slope on the harvested area. With the remaining timber being located in a 100 m wide strip along approximately 4.5 km of stream, it is unlikely that this timber will be harvested unless additional extraction roads are constructed.

Suitability to Existing Forest Conditions

The K.F.F., combined with mechanical delimbing and slashing at roadside, appeared to be well-suited to the site on which it was operating. The site is a well-drained upland site with very few springs and good ground bearing capacity. Soil disturbance was minimal and the machine was capable of operating on slopes up to 30% with little if any increase in soil disturbance. Although there were considerably fewer seedlings present following the harvesting operation, the number of undamaged seedlings should be adequate to reforest the area. A 60% stocking level should be possible as indicated by the number of plots with regeneration present. Slash was virtually absent on much of the cutover except at roadside.

Suitability for Harvesting Environmentally Sensitive Areas

Based on field observations and the results of the assessments made on this particular harvest block, it is the author's opinion that the K.F.F. system could be used to harvest, within acceptable environmental limitations, wood in riparian strips and deer yards. However, this machine should only be used on sites that have good ground bearing capacity and very few springs. The K.F.F. is suited only to clear-felling and a strip, patch or clearcut harvest method would have to be used. The K.F.F. appears to have little difficulty in negotiating slopes up to 30% provided a relatively flat area is available on which the machine can turn. Large tire size and four wheel hydrostatic drive gives the machine a low ground bearing pressure with minimum tractive effort and allows the machine to move with little soil disturbance other than compaction of the organic layer for slopes up to 30% that are well-drained sites. Cutting strips should be located to avoid all areas of poor ground strength because where ground strength will not support the weight of the machine severe ground disturbance usually results. The width and slope of the riparian zone would determine the orientation of the cut strips; wide riparian zones normally associated with steeper slopes would probably have cut strips oriented perpendicular to the stream while narrow riparian zones associated with more gradual slopes would probably have the cut strips oriented parallel to the stream. Although the K.F.F. is a less maneuverable machine than conventional equipment such as the skidder, it is felt that it will negotiate the steeper adverse slopes with less soil disturbance than conventional equipment.

In most cases the K.F.F. would only be used to harvest within riparian strips where they are adjacent to a regular harvest block. The decision of whether to use the K.F.F. to harvest within the riparian zone should only be made as cutting progresses on the regular block and the effect the machine is having on that particular site can be observed. When damage occurs on the regular block that is unacceptable for harvesting within riparian zones, an alternative for harvesting within the riparian zone will have to be chosen.

Conclusions

The K.F.F. system did not appear to cause any major problem on this particular site.

The area occupied by roads and landings was 9.9% and is approximately double the 5% of area allowed under the harvesting rules as described in the FMM. Without an effective form of slash disposal approximately 10% of the area will essentially be lost for forest production.

Machine tracks occupied 38% of the unbulldozed area and organic and mineral layer disturbance occupied 17% and 5% respectively of the unbulldozed area. The amount of soil disturbance appeared to decrease for slopes greater than 20%. Severity of disturbance did not appear to increase with increased slopes.

Very little slash remained on the block with slash accumulation being absent on 10%, light on 80%, moderate on 5% and heavy on 5% of the unbulldozed area. The 5% of area in the heavy slash classification occurred at roadside as a result of mechanical delimbing.

Regeneration potential was estimated to be not limited in 93%, moderately limited in 2% and severely limited in 5% of the plots when using either soil disturbance and/ or slash accumulation as the limiting factor.

Erosion potential was estimated to be low on 95% and medium on 5% of the area and erosion and siltation would not be expected to be a serious problem on this block.

A considerable amount of advance regeneration was destroyed during the harvesting operation and only 41% of the original softwood seedlings remained in an undamaged or slightly damaged condition. There was a reduction from 97% of plots with softwood regeneration prior to harvesting to 90% following harvesting. Even with the large reduction in advance regeneration there should be a sufficient number of seedlings remaining to reforest the area.

There is a conflict between trying to reduce soil disturbance and erosion by more uniformly distributing wheel tracks, and reducing advance regeneration damage by reducing the area occupied by wheel tracks. Where natural regeneration will be relied on to reforest the area, an optimum approach could be to reduce the area occupied by wheel tracks on areas of low erosion potential thus reducing the amount of damage to advance regeneration, and on areas of high erosion potential to operate the machine such that wheel tracks are more uniformly distributed. On areas where natural regeneration will not be relied on to reforest the area, the machine should be operated such that wheel tracks are uniformly distributed throughout the block.

Merchantable waste volume totalled 450 m^3 on the block and exceeded the 3.0 m^3/ha allowed by regulation. An additional area of 45 ha was approved for harvest but was not harvested and could have produced an additional 6 500 m^3 of wood.

With proper supervision and choice of site, the K.F.F. could be used to harvest riparian strips within acceptable environmental and economical constraints.